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FRANK B. WADE—A MASTER TEACHER

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It is indeed with a great deal of pleasure that I have the privilege today to talk to you about one of our own members who has made a success as a teacher of science. We should be grateful that we have an opportunity to honor and appreciate this man while he is still living. His ideas and contributions will be felt for many years.

Just what qualifications does Mr. Frank B. Wade have which have enabled him to obtain this rare distinction of being a master teacher? First, he has been well educated. He was born in New Bedford, Massachusetts, graduated from Connecticut Wesleyan University with a Bachelor of Science Degree in Chemistry, Wabash College awarded Mr. Wade an honorary degree of Doctor of Science in 1937, and Wesleyan University awarded him an M.A. degree in 1938. However, Mr. Wade is constantly keeping well-informed, maintaining an active membership in the American Chemical Society, being a Fellow of the Indiana Academy of Science, belonging to the Central Association of Science and Mathematics Teachers, and being a Fellow of the A. A. A. S.

Mr. Wade has been at Shortridge High School since 1903. Since that time the methods of instruction he has used in chemical education have become known throughout the United States. His ideas and methods are of such radical departure from the regular trend of instruction that some teachers would

wonder if his methods would be successful; but they have been. His main idea in teaching chemistry is not to teach subject matter, but to teach students to think scientifically and to have an appreciation of science in general. If you would visit his high school chemistry department, you would be surprised at the small amount of textbook material that is covered during the year. Shortridge chemistry students would not achieve a high score on a college entrance examination containing questions on miscellaneous facts from the last half of the text. However, the students would be well informed on the most modern ideas on the atomic structure of the atom. Perhaps the student could not tell you how to make a drawing of a 1907 high school text idea on how "sodium is prepared commercially," but he can tell you why sulphur should be an acid-forming substance. He can tell you why antimony should be an amphoteric element.

The chemistry department at Shortridge has always been large. The average enrollment in the department has been around 400 students in a school attendance of around 3000. This desire to take chemistry under the direct guidance of Mr. Wade, has been created by the students themselves. The first semester students are slightly segregated. Under the direction of Miss Leda Mae Hughes the students who have a poor high school record in mathematics or science, or have a low I. Q., are placed in an Iy group. There is never more than one special beginning class. This uses a simple laboratory manual prepared and mimeographed by the instructor. Mathematics is not stressed in this class and the group advances slowly. More facts are taught than theory.

The second semester of the first year the students who have made above average grades in Chemistry I are placed in a IIx section. Usually there are two such groups. This class uses the same text and laboratory manual as the regular chemistry II's. However, in the laboratory book there are special questions that require additional college textbook reference work. The group progresses very rapidly and usually finishes the theoretical work about two weeks before the regular II's. This time at the end of the year is spent on special project work. For example, two students team together and prepare "aspirin." The report must be written and then given orally before the group.

A new course has been added during the last year at Shortridge. It is called Semi-micro Qualitative Analysis. The ultra-modern college text "Qualitative Analysis" by Belcher and

Williams is used. The purpose of this course is to teach the best students the theory of solutions and at the same time to develop good laboratory technique. Many of the students taking this course find employment in the commercial laboratories of the city. Some of the students go into nurses' training; others go into scientific work in the army and navy. At the present time we have more jobs than there are available students. This semester there are two classes of Chemistry III. Laboratory jobs of every description await these students just as soon as they have enough high school credits to graduate.

This special course is not easy. Difficult problems on calculation of solubility product are given. The student must have an excellent understanding of standard solutions and be able to make any kind and concentration. We do not attempt to teach industrial methods of analysis. Each commercial laboratory has has its own special procedures. The factories desire students who are hard-working, honest with their results, and who can follow instructions.

This course should be investigated by every high school teacher. The saving in equipment and chemicals will interest all of you.

At the present time there are six members in the instruction staff in the Shortridge Chemistry Department. It is indeed a happy family. They work together as a unit without the slightest bit of dissension. No one could ask for a finer head of the department. Mr. Wade is known the world over as an authority on precious stones. He has published the following textbooks on his hobby: *Diamonds, A Study of the Factors That Govern Their Value, A Text Book of Precious Stones,* and *How to Buy Diamonds Wisely.*

It is a common practice for Mr. Wade to stop a member of the department and remove from his pocket a piece of paper containing a fine diamond. Usually a discussion ensues and the listener can learn more in a few minutes from Mr. Wade about diamonds than if he had read a text on the subject.

Mr. Wade's greatness lies in his keen mind, his understanding of human conduct, his definite ideals, and his friendly and gracious manner. Mrs. Wade has been an inspiration and an asset to Mr. Wade's career. She, too, is as just, as intelligent and as gracious. Teaching as a profession would rise to a higher plane if more scholars like Mr. Wade would make teaching their profession.

BIOLOGY AND THE PLANT SCIENCES IN POSTWAR EDUCATION

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Though perhaps no one can as yet predict the new world order after the conflict, certain forces are already in motion which will have a profound influence on the permanent pattern of education and of science instruction in the post-war era. In addition to the urgent but transitory problems arising from the necessity for immediate restoration of nearly 20 million American veterans and war workers to civilian pursuits, there will be new problems of educational policy arising in a politically and economically transformed world. The urgency of the need for early vocational rehabilitation of an unprecedented number of veterans and war workers will for a period of years temporarily but definitely superimpose the objectives of vocational training upon the usual goals of liberal education. These demands of technology upon education in the new world order will not only be quantitatively great but qualitatively diverse along lines as yet only vaguely discernible because we do not know what entirely new types of civilian industry are destined to arise in the post-war period. The reconversion of industry from a war footing to a peacetime basis will require considerable time and it seems safe to assume that during this transition period thousands of young people will be encouraged to withdraw from a swollen labor market by returning to school for several years after the war. Severe or protracted post-war unemployment will encourage extended periods of education for those able to seize the opportunity and as the period of training lengthens our curricula will tend to supplement vocational training with increasing amounts of liberal and cultural education. There is consequently, not only interest in but considerable justification for the immediate formulation of educational devices which serve both vocational and cultural objectives in the changed world order.

For a variety of reasons, there will probably be a tremendous demand for biological instruction. Cessation of hostilities usually inaugurates a great resurgence of interest in human values as opposed to the dominant technological and mechanized activity of war itself. The factors of human well-being are intimately

intertwined with plant and animal science, especially with their applications in agriculture and medicine. The demands for world-wide service in agriculture and medicine are too obvious to require more than mere mention. These sciences are also surrounded by a host of peripheral services requiring biological training. During the current conflict, biologists unlike the personnel in the physical sciences and their industrial technologies have not generally been accorded deferment from military service with result that the supply of recruits for biological vocations has been more seriously depleted than in physical science, mathematics and engineering.

The great humanitarian service which applied biology will be called upon to contribute to healing the bodily and spiritual wounds of mankind, coupled with the reduction in numbers of biologists now being trained, will create a sharp demand for professionally trained specialists not only in agriculture and medicine but in the fields of nutrition, sanitation, recreation and public health. Perhaps no feature in the huge mobilization of America's man and woman power for the war has been more disconcerting to the nation than the rejection of approximately 25 per cent of the inductees and the dismissal of an additional 1,200,000 men from military service itself because of physical or mental inability to qualify for active field service. These statistics give us an appalling picture of the state of America's health. Unfortunately this state of affairs will be gravely aggravated by an unprecedented number of war casualties. To the list of battle casualties, we shall have also to add a huge but as yet unpredictable host of diseased bodies and minds. The possibility of epidemics of contagious tropical diseases, which may be introduced on a large scale by returning veterans, is already giving serious concern to medical and public health authorities. In anticipation of some of these heavy demands some provision is already being made for the training of an increased number of medical personnel but little if anything is being done in the realm of agriculture and other phases of biology to meet post-war needs. The foregoing are but a few portents of the future with which biology will be closely associated.

In addition to these, there are still other needs. The rapid expansion of social studies, already under way prior to the war, will receive added impetus from sociological problems arising in the post-war world order. Since our social order deals with living beings and rests largely upon a biological foundation, ex-

pansion of instruction in the social sciences is destined to have its impact upon biology as a collateral science. Current interest tends to center increasingly in those phases of biology which underlie legislation on health, housing nutrition, conservation, agriculture, and medicine. Eminent civic leaders and school administrators have already recommended that biology and science education in general be presented in terms of its bearing on social action. Because the social sciences rest largely on a biological foundation and deal with human beings, the better the understanding of biology, the more effective will be the sociological program based thereon. This is but another way of stating that biology is a logical starting point in what promises to be the major program of social action growing out of the present world crisis. The influence of biology in the field of social sciences is already evident in the adaptation of the concepts of ecology to problems of human populations and eugenics. This new sociology will be added to man's ever-dominant interest in his own biology as a living organism. It seems safe to predict a closer integration of pure biology with the social sciences than we have ever had before.

These trends will also affect the future training of teachers. Biology teachers will find tangible inducements to acquaint themselves with the social sciences as they embody applications of biological principles. If science teachers become familiar with the major problems of sociology, they would be able to indicate more effectively the objective aspects of science which are of tangible use in socio-political programs. Considerable confusion exists among the laity, for example, as to the character of eugenics because the biology of that subject is not yet adequately differentiated from its purely sociological aspects. We are also confronted with the necessity of making social adjustments concurrently with rather than long after new technological applications of science. The existence of these conditions explains the desire of statesmen and educators to awaken a greater public interest in and to improve understanding of politico-economic problems through the instrumentality of our public schools. There is already an increasing demand for biology and home economics teachers familiar with the latest scientific developments in these areas.

The importance of biological education in relation to the above trends is readily evident. The human body is destined to receive more attention in schools than ever before. Greater and

more widespread knowledge of diet, housing and health will be disseminated in our schools probably to parents as well as to youth. The biology teacher will in the future be called upon to assist much more extensively with the scientific phases of public health and recreation. The state of New York has already assumed leadership in making health instruction mandatory in public schools. Instruction in nutrition will be pointed to improved health and more desirable dietary habits of the nation. Changes in human nutrition will in turn probably lead to new practices in agriculture.

As one turns from the broader civic aspects of education to those dealing more specifically with the school procedure, we also find significant changes under way. These involve major changes in methods of instruction, in course content and in teacher training. Though requirements for certification of science teachers may not be immediately raised on a national scale because of the acute shortage of trained personnel, there is nevertheless already a concerted trend in this direction as indicated by the stipulation of a master's degree as a minimal requirement for certification of high school science teachers in certain states. As the scope of instruction in the life sciences increases in breadth and the emphasis on integration of knowledge grows, biology teachers will feel impelled to enlarge their horizons by serious study in related fields in order to assist their students in grasping the interrelations and applications of science to human affairs.

In connection with educational methods, it may be pointed out that certain as yet inconspicuous but nevertheless widespread tendencies have been gaining ground. There already exists a definite movement in the direction of a balanced earn-learn program. This idea of providing realistic job experience as an integral part of the student's schooling is by no means new and it has long been successfully practiced at the well-known Berea and Antioch Colleges and more recently at the University of Chicago. This policy, of course, has as its prime objective the immediate employability of college graduates and the establishment of contacts which are helpful in obtaining their first full-time job. The significant recent development has been the rapid expansion of this method of education as fostered in the prewar period by outside subsidy from the United States National Youth Administration and during the war by subsidy of the federal E. S. M. & W. T. programs. Government and industry

are currently urging immediate adoption of such a plan for the post-war period.

The earn-learn program envisions enlarged opportunity for complete or partial self-support and bona fide job experience while the student is in school. Self-support aims to provide not only the means to education itself for those who would otherwise be barred, but to introduce the elements of morale, self-confidence and job apprenticeship as well. Pre-war census figures make it evident that education was not accessible to some three and one-half million youth of 14 to 17 years of age for financial reasons. Only 11 per cent of our college-age, pre-war population were actually enrolled. Of the 21 million high school and college age group, nearly two-thirds were excluded from schooling by pitifully small financial margins. During the depression, most of the 13 million out-of-school youth were also unemployed and, ironically, often prevented from obtaining jobs because of child labor laws. The very laws which had originally been idealistically enacted to prevent industrial exploitation of children, in the depression penalized preeminently the very group they were designed to protect. This grave situation was subsequently aggravated for out-of-school youth by restrictive regulations of trade unions against minors. Before the war America was rapidly recruiting a vast army of disillusioned adolescents, many of whom become politically militant in their economic desperation.

The youth crisis became nationally acute and the federal N. Y. A. and C. C. C. stepped in at this juncture to forestall the possibility of fascism and communism in America. The National Youth Administration was started in 1935 as an emergency relief measure for the purpose of removing school age children from the labor market by financially subsidizing their return to school. It is interesting to note that by creating an opportunity to earn from five to twelve dollars per month, 650,000 children were restored to school. The Civilian Conservation Corps proved to be highly successful as a job-training project and enjoyed about a 40 per cent annual turnover due to acceptance of C. C. C. graduates into permanent employment as compared to only one per cent for school age youth registered with federal unemployment agencies. The C. C. C. obviously possessed spot value in job training which the public school education lacked.

As a relief measure, federal subsidy thus came into American education on a large scale for the first time in the nation's history. As unemployment diminished both the N. Y. A. and

C. C. C. were nevertheless continued for several years largely as a nation-wide experiment with the earn-learn program. Though the N. Y. A. and C. C. C. have been eliminated, the E. S. M. & W. T. program still continues under federal subsidy. We thus have the precedence, policy and experience necessary to develop a comprehensive national earn-learn program which can be immediately expanded on a large scale and rapidly modified to meet post-war exigencies. Problems similar to those of the pre-war depression may again arise with collapse of the present war boom and federal subsidy may again be necessary for education designed to facilitate employability of American youth.

One may ask how this shift in educational method will affect biology. The answer may prove to be that biology will be called upon to prepare students for gainful employment in its applied phases at technical as well as at professional levels. Formulation of details for such a program may not be difficult in vocational high schools and agricultural colleges, but real administrative ingenuity may be required to create such projects in our liberal institutions. One immediate problem will be that of the time schedule. Daily class room meetings of one hour are poorly adapted to realistic laboratory work in biology or to earn-learn programs for the student. The length of laboratory periods may have to be increased and to a large degree biology courses may be transferred from the laboratory to the greenhouse and the out-of-doors. Such biological information can be given sound scientific values and made more valuable to the student because he acquires information directly instead of through the textbook or lecture. The imperative need for wider information on conservation in all its aspects will also give further impetus to field work. Despite the informality of method, substantial quantities of sound biological information can be effectively inculcated in the field and laboratory under informal auspices. But the schedule of courses must provide realistically for adequate time for field work and for laboratory periods long enough to complete biological experiments.

Obviously, if the earn-learn program is expanded and the methods of instruction become less formal, there is also bound to be a commensurate effect on subject matter. Such tendencies are already evident on the plant side of biology, as can be readily gleaned from recent textbooks. Instead of presenting the leaf, stem, root, flower, fruit and seed like the pieces of a jigsaw puzzle, modern botanists endeavor to present the plant as a dy-

namic entity, preferably in its natural environment. On the plant side of biology, it seems logical that students like the gardener should first meet the plant as a seed which they are taught to grow. Such living cultures soon become the students' pets, and they unconsciously respond to the subtle lure of life unfolding in their care, even if only in an ordinary flowerpot. in a soilless culture, or in an aquarium. Incidentally, the student always has the plant as a whole before him instead of as a miscellany of its separate parts. Experimentation with the living plant becomes something like manipulation of a mechanical gadget and provides abundant opportunity for student activity as his understanding increases. The teacher guides the student in finding answers to questions in the plants themselves rather than in textbooks by encouraging experimental testing of hypothesis and theory. The developmental approach with living plants readily sets the stage for the introduction of the functional or applied side of botany without in any way excluding cultural or soundly scientific phases of the subject.

Recent developments in plant science offer the biology teacher a number of new yet definitely scientific experiments. The lay press has, for example, built up widespread interest in commercial soilless culture of plants, a procedure readily adaptable to the classroom. Students are amazed by what they themselves can accomplish merely with water and a few pinches of certain common salts. Soilless cultures lend themselves not only to actual demonstration of economically important mineral deficiency diseases of crop plants but also to spectacular demonstration of recovery therefrom when missing chemical elements are restored. Plants grown in soilless cultures also provide excellent material for widely used tissue tests for mineral deficiencies. Such experiments can also be combined with studies on the effects of plant hormones and vitamins. Production of fruits by use of hormone sprays or salves is readily feasible and the seedlessness of such fruits creates enough interest in reproduction to enable the teacher to convey readily the scientific aspects of the normal reproductive processes in plants.

Other important uses of plant hormones involve the rooting of cuttings. The latter has recently been of great significance to the war in the propagation of cuttings from pine trees which produce exceptionally large quantities of turpentine. Pine cuttings can be rooted only by means of these rooting chemicals and perfection of vegetative propagation has great possibilities.

Serious problems of spoilage of perishable produce in transit and storage can be readily demonstrated with living cultures by biologists with an understanding of the usual destructive microorganisms. Laboratory culture and inspection of disease pathogens collected in the field are easy, inexpensive, interesting and thoroughly scientific exercises. The use of fermentive bacteria and molds in production of alcohol and acids from agricultural products can be readily demonstrated in an interesting way with live cultures. The antibiotic effect of penicillin produced by growth of the mold, *Penicillium notatum*, in a live culture of bacteria is a simple but dramatic experiment, easily within the ability of a student to perform individually.

In the field of genetics one of the most important scientific and practical new developments has been the production, by means of colchicine and other drugs, of new types of plants as a result of changes in the chromosome number. Many of the resulting polyploids are already in production because of their superior commercial value and vigor. Future advances in this field will be of increasing importance in agriculture. Use of colchicine and well designed exercises on segregation of hybrids after cross-pollination by students add a welcome experimental activity to the predominantly descriptive aspects of instruction in plant genetics.

A graft of a tomato scion on a potato rootstock, for example, gives rapid results and is easily made to provide training in methods of grafting. The production of potatoes and tomatoes on a single plant always arouses interest and vividly demonstrates that different varieties can be grafted, as is commonly done with tree fruits and shrubs in commercial horticulture. Herbaceous grafts are simple, rapid enough to maintain interest and yet demonstrate basic practical methods. The use of short-lived species giving rapid results constitutes an important item of teaching technique which is of great convenience to teachers charged with the care of experimental materials.

Most students have heard of the use of canaries in warning miners of the presence of monoxide gas. Few students, however, have seen the drooping of leaves in the epinastic response of tomato plants in the presence of gas and as a test for gas leaks, a demonstration easily workable in an ordinary laboratory period. In fact, one can go farther and by the same epinastic test demonstrate the natural emanation of ethylene gas from ripe apples, bananas, and other fruits which paves the way for an

explanation of their normal ripening. Such experiments also set the stage for a discussion of the scientific principles underlying the commercial process of coloring and ripening of fruits such as bananas and citrus by ethylene gas. These are but a few specific illustrations of contemporary developments in biology capable of providing effective, dynamic classroom activity.

If the earn-learn program with its less formalized classwork and emphasis on functional values is to influence post-war education, the teaching of biology can be readily adjusted to it and itself be considerably vitalized thereby. The diversified character of functional biology will be refreshing to those who have so long employed the older descriptive approach. Diversity of activity and understanding of scientific logic as required for a study of development in living organisms will place a premium on thorough teacher training and good pedagogy. The fine subjective art of teaching will in the future have to be more subtly employed in presentation of the strictly objective methods and facts of science, yet informal modes of instruction need not result in elimination of truly scientific attainments or mastery of the principles of science.

The close of the war will inevitably bring extensive curricular changes. While it is only proper that education should meet new social needs, it will be necessary for administrators and teachers to anticipate these needs, to safeguard standards and to avoid the assumption that change alone constitutes educational progress. The place which science and biology assume in the new educational order will in large degree be determined by the thoroughness of the study of new social needs, by the preparation of a comprehensive program of science instruction supported in a unified way by scientists throughout the nation. The large educational and biological societies of America have the opportunity and perhaps the obligation of leadership in placing the judgment as well as the talent of science and biology at the disposal of the nation in peace as it has been in war. Our schools and industry stand ready to consider any educational program for science and biology which represents the consensus of scientists themselves.

To be what we are, and to become what we are capable of becoming, is the only end of life.—ROBERT LOUIS STEVENSON.

THE TEACHING OF MATHEMATICS AS VIEWED BY AN ENGINEER

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Diderot, a French materialist, was visiting the Russian court, where his elegant rhetoric amused the nobility and tended to undermine their religious faith. To discredit him the Tsaritsa informed Diderot that a mathematician had proved the existence of God, and she arranged a public debate. The distinguished mathematician Euler faced the brilliant Frenchman and pronounced with the utmost solemnity: "$(a+b^n)/n=x$, donc existe—répondez!" Diderot, innocent of any mathematical knowledge, retired hastily amid the titters of the assembled court, confined himself to his chambers, and soon after returned to France.

Mathematics is a language. Translated into English the above quotation from mathematics and French would read: "A number a added to a number b multiplied by itself n times and this result divided by the number n yields another number x, hence God exists—answer!" As may be noted from this example, the numbers and symbols of mathematics are the nouns of the language, the signs of operation are verbals which form phrases or clauses, and the signs of equality and inequality are the verbs without which a mathematical statement is never complete. Subscripts and superscripts are adjectives pointing out particular nouns, and adverbs sometimes occur ($y\cong 2.4$, the number y is approximately equal to 2.4), but I think there are no interjections. An engineer may lie but he cannot swear in mathematical language.

An engineer is a person whose primary vocational function is to satisfy those felt needs of men which can be met by physical systems—machines and commodities. To fulfill his function adequately an engineer must have a true understanding of physical causes and effects and of the reactions of physical systems in relating one to the other. In the physical world forces are the motive factors, the causes of change, and the effects they produce are usually strains or motion. The physical systems on which forces act have properties which relate the cause to the effect in definite ways; they impose conditions or restraints which relate cause to effect in a manner unique to a given physical system.

For example, men feel a need for heating pads for invalids in bed or for airplane pilots at high altitudes. An electrical engineer must know how the desired effect (heating) is related to the cause (voltage or e.m.f.) and to the properties of the electrical system (length, cross-sectional area, and resistivity of the wire of the heating coil), if he is to design a satisfactory heating pad. He would also need to know something about electric insulating materials, heat flow, strength of fabrics, etc., to carry through the complete design.

We have said that physical causes (forces) give rise to effects (strains or motions) subject to certain conditions or restraints imposed by the physical systems on which the forces act. The relationships between causes and effects are set forth in the laws of physics and chemistry. Physical laws have been well defined, I think, as statements of the unvarying relationships between varying physical quantities. Doesn't this definition suggest the mathematical concept of a function? A function, to me, is a relationship between quantities such that if values are assigned to all but one, the value of that remaining quantity is then determined. The functional relationship between quantities is specified in terms of the operations which must be performed on the given quantities in order to obtain the unassigned quantity. The form of the function (type and sequence of the operations) imposes certain conditions or restraints on the derived value of the unassigned quantity in just the same way that a physical system imposes conditions or restraints on the effect obtained when given forces are impressed on that system. Out of that correspondence between the nature of mathematical functions and the behavior of physical systems arises, it seems to me, the possibility of expressing physical laws in mathematical equations. So mathematics becomes the language of the engineer in his attempts to understand and predict the quantitative aspect of the changes of physical systems. Ability to formulate, manipulate, and interpret statements is essential to sound, creative engineering.

This brings me to one critical point I should like to suggest. *Much of the mathematical instruction given students in our present courses tends to develop forms of insanity.* Perhaps that is an extreme way of stating a thesis you have probably heard before. Let me expain what I mean.

As I understand it, some forms of insanity are caused by and

characterized by the failure of a person's thoughts and actions to correspond to observable reality. The symbols he uses in his thinking and his speaking are not related to, or are imperfectly related to the things or events for which they are supposed to stand. Hence his actions, based on false attitudes or beliefs, become more or less irrelevant or inimical to successful adjustment to his physical and social environment. Misconceptions regarding physical nature lead to the more obvious forms of insanity involving hallucinations and attempts to build perpetual motion machines. Lack of correspondence between thought symbols and reality in the psychological and social realms lead to imaginary fears of other persons, prejudices and ideological conflicts, and extremes of selfishness and sadism, which are inimical to the highest development of individual or group.

Analogously in mathematics, it seems to me that many students fail to understand the relationship between mathematical symbols and the realities for which they stand. Hence, their actions in applying such knowledge may be irrelevant or false to the situation. For instance, engineering students are taught in an algebra class that in the equation $P=VI$, we must multiply a number V times a number I to obtain a number P. They might even be told that P stood for power, V for voltage, I for current. But, faced with the practical problem of determining the current drawn by a 50-watt light bulb connected across a 110-volt line, do you think they could apply the equation to get the right result? This is so simple a problem that some would, though it is indeed a daring step to change the form of the equation to $I=P/V$ in order to make the solution. Some would be bothered by the relationship between the units of watts and volts even then. Again, in electrical engineering $R=V/I$ is the equation for determining the value of a resistance R when a voltage V across its terminals causes a current I to flow through it. Some students, given a battery with terminal voltage V and delivering a current I, will simply divide V by I to find the internal resistance of the battery. Such behavior is insane, from an engineering point of view, for the relation $R=V/I$ applies to a resistance and not to a battery.

I am not implying that teachers of mathematics should explain Kirchhoff's laws for electric circuits. I mean only to point out that students from their mathematical training have usually not come to relate mathematical equations to physical realities,

the symbols to physical quantities. The symbols used in algebra, trigonometry, analytic geometry and calculus have usually stood for numbers only, not for physical magnitudes specified in terms of a unit of measure and a number of times that unit is taken. Hence, students fail to grasp the meaning of mathematical equations, how the functional dependencies relating the symbols correspond to the conditions or restraints relating cause to effect in the world of reality. Students know very well that $Q=rt$, where Q is a quantity, r is its rate of flow, and t the time. But how many would think to use the relation in calibrating their water meter at home? Or, having learned the intricacies of geometric series and exponential functions, how many engineers could advise their wives by how much to increase the yeast in a given recipe if the time of rising of the dough were to be cut in half?

It seems to me that a good deal of our mathematical training is centered too much on the formal manipulation of the symbols, rather than on an understanding of the correspondence of mathematical language with reality. Believing that education should relate to important aspects of living, I feel that a more practical emphasis would be desirable, and believe that a sound, useful superstructure of theory can be built only on concepts grounded in practical personal experience. Unless mathematical training can be brought more "down to earth," it seems to me that students may turn from it as they have turned from other disciplines that came to overemphasize the techniques for manipulating symbols rather than the significance and meaning of those symbols in life, such disciplines as English composition when it emphasizes grammar and style more than ideas expressed, religion when its symbols lose relation to living, and logic when it becomes engrossed with manipulation of syllogisms more than evaluation of evidence. The situation seems particularly grave for engineers, for they are called on to use mathematics more in relation to reality, and their shortcomings in this area become obvious and harmful more quickly.

In closing, let me outline what I believe to be the important elements in the mathematical training of engineers.

1. The training given must enable them to formulate physical problems in mathematical terms. This involves some or all of the following steps:

a. Sketching a system, setting down known data, and stating precisely what it is desired to determine.

b. Specifying the physical forces acting and the properties of the physical system on which they act.

c. Deciding upon the physical laws involved and the restraints or conditions they impose upon the relation of cause to effect. Assumptions need to be stated and kept in mind.

d. Defining variables precisely, involving choice of reference systems in space, positive directions, and units of measure. Oh, the needless headaches over minus signs! If positive direction of the x-axis has not been specified, how can one hope to tell whether the symbol x stands for a positive or a negative quantity? And why do mathematicians spurn any consideration of units of measure and dimensional homogeneity of physical equations?

e. Expressing the physical laws in terms of the defined symbols correctly and completely.

The process of formulating physical problems in mathematical language is usually omitted almost entirely in our educational scheme, I believe. I know I left it out when I was teaching for the mathematics department, I didn't have time.

2. It is in the next step, manipulation of the mathematical equations, that our training has been strong. Yet the usual training in solving problems deals almost exclusively with the exact manipulation of equations. Engineers need also to know when and how to make approximations that will simplify their calculations. And they need to know something about the representation of functions in tabular and graphical form and something about the information that can be obtained from such representations—by means of differencing, measuring slopes and areas, using logarithmic and semi-logarithmic graph paper. Also, couldn't mathematics teachers help both themselves and engineering students by relating the presentation of logarithmic functions to an explanation and use of the slide rule?

3. Finally, an ability to interpret the results of mathematical manipulation is vital to an engineer.

a. He must have some way of checking the answer, perhaps by knowledge of relative magnitudes from his past experience, perhaps by parallel or check calculations.

b. He should be able to translate the mathematical result into descriptions in word language of the predicted behavior of the physical system. He should be aware of the power of graphs in presenting a great deal of information powerfully and concisely.

c. And, above all, he must be aware of the physical significance of the mathematical result, both its meaning and its lack of meaning. *Mathematical equations do not think.* The results obtained will be consistent, assuming correct manipulation, only with the assumptions underlying the initial formulation of the problem. And the solution must be restricted to a physically meaningful region in time or space. Things may have been quite different at times less than zero, before a force had been applied. And falling bodies stop falling when they hit the earth, instead of going on to minus infinity! And the growth of populations or of money invested at compound interest, exponential rises, couldn't keep going indefinitely.

It seems to me that models and classroom demonstrations would help engineering students to acquire the all-important appreciation of the physical significance of mathematics, to get the "feel" of equations as they correspond to physical laws. This point was well illustrated last year in a class in Mathematics for Engineers which I was teaching. We had solved the differential equation of motion for a spring and mass oscillating in simple harmonic motion and had discovered that the frequency of vibration (f) was related to the mass of the body (m) and the stiffness coefficient of the spring (k) by the relation $f=(1/2\pi)\sqrt{k/m}$. One of the students who had taken more mathematics courses than the others and was farther along the road toward mathematical insanity, indicated that he had seen and derived the relation often enough but challenged me to prove that the equation really meant something physically, since I had been stressing that point. So we found out a spiral spring and a couple of chunks of iron. We weighed the iron pieces and found the stiffness coefficient of the spring by stretching it a measured distance. Then, after a bit of discussion over the proper units in which k and m should be expressed, we calculated the value of frequency f predicted by the equation. Finally, we hung the weight on the spring, pulled it downward, and released it suddenly when the cheerful skeptic, watch in hand, shouted "Go." For thirty seconds of thick silence our heads bobbed up and down with the weight. Then a quick slide-rule division of counted vibrations by time yielded an experimental value for frequency. Two per cent error—good enough for engineers! Thank heaven, mathematics was reliable! Or was it, in our mathematician's mind, the world of reality which had been vindicated?

TRANSMUTATION AND ARTIFICIAL RADIOACTIVITY

J. NOEL CORBRIDGE
Garden City High School, Garden City, New York

The idea of transmutation, which simply means changing one element into some other element, probably started with the alchemists. These men were the forerunners of the modern chemist, and had two main objectives. One was to find the "elixir of life" to keep people perpetually young, and the other was to change other substances into gold. While modern science has not discovered the "elixir of life" (although its applications have prolonged the life span by many years) it has succeeded in bringing about transmutation.

The modern story begins with a French scientist named Henri Becquerel who was interested in phosphorescent substances; those which glow in the dark after they have been exposed to light. Becquerel, having learned of Röntgen's discovery of invisible x-rays, decided to see whether any phosphorescent substances would affect a photographic plate covered with black paper. If they did, it meant that they were giving off invisible radiations. He found that anything which contained the element uranium would register on the covered plate. This phenomenon he called radioactivity. He turned the problem over to the renowned Curies, Marie and Pierre, who discovered that uranium was not the only substance which was radioactive. Research along this line led to the discovery of a new element, radium, which is many times as radioactive as uranium.

Radioactive substances give off three types of rays or particles:

> Alpha particles, which carry a double positive charge and are in effect, the nucleus (central part) of a helium atom; Beta rays, which carry a single negative charge and are a stream of electrons; and Gamma rays, which are very penetrating rays, similar to X-rays.

Here is a natural transmutation. When a radioactive substance gives off a particle, a different element is formed. For example, uranium gives off an alpha particle and becomes uranium X_1 which in turn gives off a beta particle and becomes uranium X_2. After a few more transmutations we get radium, which in turn gives off particles and, after going through several other radioactive elements, finally becomes a stable form of lead. These transmutations were going on at the time of the alche-

mists and for many millions of years before. Deductions from a knowledge of radioactivity are used to estimate the age of the earth.

In this discussion we are primarily interested in the alpha rays. Let's see how they are detected. A simple device called a Geiger counter is used (Fig. 1). It consists of two metal plates (M) in an enclosed space (C), called an ionization chamber. The

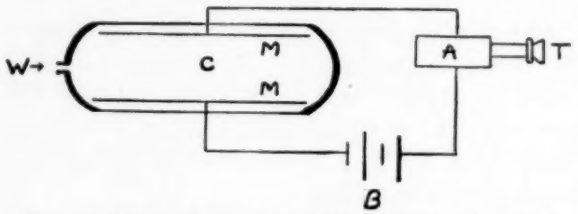

FIG. 1. Geiger Counter. A device for detecting and counting alpha particles.

plates are connected to a battery (B), an amplifier (A), and a telephone receiver (T). As each alpha particle enters a small window (W), it makes itself known by a sound in the telephone receiver. What happens is that the alpha particle knocks off a few electrons from the molecules of air, which then become conductors for the electric current. The current passes across the space between the plates, is amplified, and causes the sound which is heard in the receiver. In this way alpha particles are detected and counted.

In 1919, Rutherford, an English physicist, passed some alpha particles through nitrogen gas. He found that another type of radiation, hydrogen atoms with a single positive charge, was

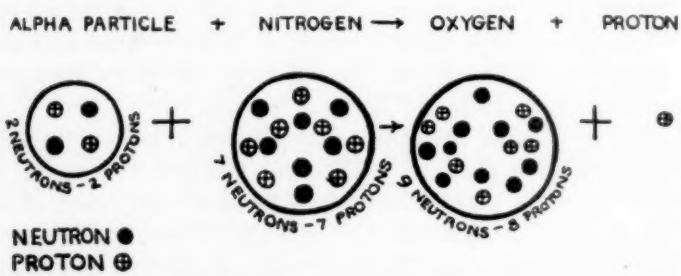

FIG. 2. Rutherford's Original Transmutation. Nitrogen bombarded with an alpha particle becomes an isotope of oxygen and a proton is liberated.

given off. These new particles, called protons, seemed to come from an explosion of the nitrogen nucleus which was being bombarded by the alpha particles. But still more important from our viewpoint is the fact that, because of the disrupting of the nitrogen nucleus, a new substance, a form of oxxgen, was produced! (Fig. 2). Here was an example of artificial transmutation, just the type of thing that the ancients sought.

Rutherford continued his work and brought about many nuclear transformations by bombarding the lighter elements with alpha particles. He could not do it with the heavier elements because the positive charge in the nucleus became great enough to repel the positively charged alpha particle. Further transmutations waited for the discovery of the neutron in 1932. This particle has approximately the same mass as a proton but has no electrical charge and is not repelled by the positive nucleus. Fermi, in Rome, worked on the elements of higher atomic weight, and, at the present writing, all of the elements, except helium, have been transformed into other elements by this neutron bombardment. They have not been transformed into any other element, however, but only into ones having about the same atomic weight as the element which is transformed, and then only in amounts which are very, very minute, but detectable.

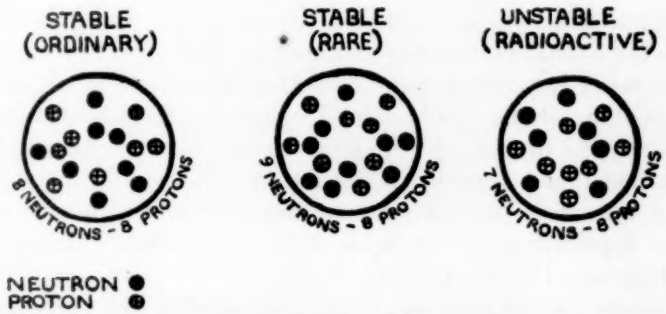

FIG. 3. Isotopes of Oxygen. Note that the atomic number (number of protons) is the same in each case, but the atomic weight (sum of protons +neutrons) is different.

We have said that Rutherford transformed nitrogen into a form of oxygen. Does this mean that the element oxygen exists in more than one form? The answer is yes, and so do the vast majority of the elements. These different forms of the same element are called isotopes and have the same atomic number

(number of protons in the nucleus), but a different atomic weight (number of protons plus neutrons) (Fig. 3).

A large number of the isotopes that are produced by bombardment are radioactive because the nucleus is not stable. For example, if we should bombard nitrogen with a deuteron (a particle consisting of one proton and one neutron) we would get still another isotope of oxygen, this one with 8 protons but only 7 neutrons, and a neutron would be liberated.

This radioactive form does not exist very long. Half of it will have disappeared in 126 seconds (the half-life period). It gives off a positron which is an electron with a positive charge and becomes an isotope of nitrogen (Fig. 4).

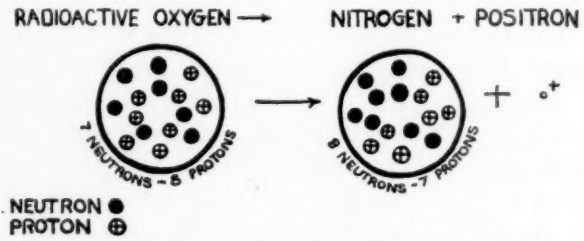

FIG. 4. Radioactive oxygen gives off a positron and becomes an isotope of nitrogen.

This attendant discovery of artificial radioactivity is much more important than the original one of transmutation because of its many important uses. Work has been done in obtaining information about undiscovered elements, the absorption of iodine by the thyroid gland, and an insight into the distribution of carbon taken into the plants during photosynthesis, to cite just a few cases. We are only on the threshold of many other useful applications in the fields of biology, botany, chemistry, and therapy. The future looks bright!

How does artificial radioactivity help us with these problems? Each radioactive atom, because of emission of particles, can be readily detected with a Geiger counter, even though the amounts involved are so small as to be unweighable. It is just as though each atom wore a big red tag which distinguished it from other non-radioactive atoms. Because of this, these atoms can readily be followed through even complicated chemical changes.

Let us examine in a bit more detail an illustrative case or two. Chemists have long considered that if two ionic compounds are

put together in solution they exchange their ions (charged atoms), but it remained for the discovery of artificial radioactivity to prove the existence of these exchange reactions. Suppose we put some sodium chloride, with the sodium ion radioactive, into non-radioactive sodium bromide in solution. We can show that the "tagged" ions of sodium in the sodium chloride almost immediately became distributed between the two compounds according to the laws of chance, showing that the ions really do change places. It is just as though there are people on both sides of a street. By looking at any one time it would be impossible to tell whether they had changed sides or not, but if we put big red tags on the people on the north side, then as soon as we see any red-tagged people on the south side we know that there must have been some exchange.

FIG. 5. A drawing made from a radio-autograph by Dr. J. G. Hamilton, showing the distribution (light areas) of radioactive phosphorus in a tomato plant.

Ballard and Dean did some work in connection with the study of the effect of different soil treatments with radioactive phosphorus on the absorption by the plant. They placed radioactive phosphorus around the roots in different ways and at different depths and detected by means of these tracer atoms, as

they are called, the amount that was taken into the plant. Some of the significant results were that very little phosphorus was absorbed by surface treatment, but considerable was absorbed if the phosphorus was placed at the bottom of the roots, though not until after a week had passed. A very interesting method is brought into use to detect the position of the phosphorus absorbed by the plant. The plant is simply placed on a photographic plate and because of the emission of the particles an impression is made on the plate which shows the concentrations of the phosphorus. Fig 5 shows the distribution very clearly. The photographs taken this way are given the intriguing name of radio-autographs.

Two other concepts which might be of interest to consider briefly are the transuranic elements and atomic power. When an element is bombarded with a neutron, the new element which is formed ordinarily has one more proton; i.e., it has an atomic number one higher. An intriguing problem is presented when we consider what would happen if we bombard uranium, the element which has the highest atomic number (92) of any of the natural elements. Fermi did this and got an element which he thought was element #93. Other investigators followed and obtained elements which they put beyond uranium, even up to elements #97 and #98. However, when the position of these elements was checked, it was found that the investigators were in error. This brought about a mystery as exciting as any that Sherlock Holmes might have tried to solve. What were these elements? Remember that the quantities involved were unbelievably minute. The trail was followed by many of the leading investigators in the world. The solution was finally reached when two German scientists, Hahn and Strassman, identified them as isotopes of lighter weight elements which were fairly well known, barium and lanthanum. Great importance was attached to this discovery because every physicist knew that if a heavy element like uranium broke into two much lighter elements, large amounts of atomic energy would be released. This action is called nuclear fission. A few pounds of U-235, i.e., uranium with an atomic weight of 235, would be enough to blow a large city right off the map. Even if only a teaspoonful could be obtained its energy would take an airplane around the world. All that remains to utilize this tremendous power is for someone to isolate it—not too bright a prospect.

Note: Acknowledgement is hereby given to Jean Fanning for her drawings.

SCIENCE AND MATHEMATICS IN EDUCATIONAL PROGRAMS FOR RETURNING SERVICE MEN AND WOMEN

*Recommendations by the Cooperative Committee on Science Teaching**

Confronted with the great variety of "post-war planning" reports and the array of rather conflicting data as to the extent and nature of the educational plans of returning service men and women, teachers and administrators may well be concerned with the kinds of schools and courses which will be most suitable in the years immediately ahead. To help orient science and mathematics teachers and administrators in colleges and secondary schools with respect to the place of science and mathematics in the educational programs for those returning from service, the following report has been prepared.

In a recent report of a study conducted by the Research Branch of the Morale Services Division, Army Service Forces,[1] it was stated that seven per cent of the white enlisted men in the United States "think that they will actually go back to full-time school or college after the war," regardless of government aid, and more than half of these even if they have a "good job" offered them. An additional 28 per cent of the men indicated that they would go back to full-time school if government aid were given. Seventeen per cent indicated that they expect to return to part-time school or college. These findings are suggestive of the size and complexity of the domestic post-war educational problem, although they cannot be taken as an accurate forecast. It is clear that many service men and women will want further education, and many of them will not want or will not be prepared for education at the college level.

The problem with which this report deals concerns the training, for a relatively short period of about a year, of returning service personnel who desire instruction below the college level. This is a new problem which cannot be met satisfactorily by

* The Cooperative Committee on Science Teaching consists of representatives of five scientific societies, as follows: American Association of Physics Teachers, K. F. Lark-Horovitz and Glen W. Warner; American Chemical Society, B. S. Hopkins and Martin V. McGill; Mathematical Association of America, A. A. Bennett and Raleigh Schorling; National Association for Research in Science Teaching, G. P. Cahoon and Robert J. Havinghurst; Union of American Biological Societies, W. F. Loehwing and Oscar Riddle. Chairman of the Committee is Robert J. Havinghurst, University of Chicago. This report was edited by G. P. Cahoon, Ohio State University.

[1] Soldiers' Attitudes Toward Post-War Education, *Education for Victory*, Vol. 2, No. 17, March 3, 1944.

existing programs either in the usual secondary school or college. In general the types of courses desired will fall into two groups: (a) technical or semi-technical courses; (b) vocational courses. Such courses can be provided in junior colleges, technical institutes, agricultural schools and business colleges. There may be some students who will be interested in general education courses below the college level. These can probably be provided by junior colleges or by some special modification in colleges or universities. The present report is not concerned with the groups who will take either technical or general education courses at the regular college or university level.

It is assumed that these short courses above the high school level will be on a basis not necessarily leading to a college degree. It would seem desirable that some evidence of ability and suitable "readiness" for entrance into such courses be determined. This might be accomplished by means of objective "screening" or aptitude tests in addition to whatever other data the returning service man or woman might bring from his military school and service experience.

While the programs suggested will, in general, aim at rather definite occupational skills and serve as vocational preparation, it is essential that the fundamental sciences basic to such occupations shall be emphasized and form an integral part of the program. Some specific suggestions for mathematics and physics, chemistry and biology, in such short below-college-level courses follow.

Mathematics and Physics

For men and women returning to civil life from the armed forces and seeking education at a below-college level, it seems clear that mathematics should be taught as an applied subject, in combination with other sciences. The experience of the armed forces in training men has indicated that purely academic training in mathematics without applications is not useful in preparing men for technical jobs. Consequently discussion of mathematics is combined with that of physics in this report.

The program in mathematics and physics at the below-college level should be adapted to (a) persons having occupations of their own preference, who desire further training, and (b), those without specific occupational choices who nevertheless are aiming at some kind of technical work.

The first group can enter specialized courses in engineering technology or agricultural technology or in business. Subjects to

be taught in such courses would be: shop mathematics, applied physical science, machines, electrical appliances, telegraph, telephone and radio repairing, refrigeration, farm machinery, direct current electricity, accounting, and mathematics of finance.

For the group without specific occupational goals, there should be basic courses in general physics, algebra, geometry, and the elements of trigonometry such as are applied in surveying and navigation. These basic courses should have a maximum of applications as illustrative material.

For men hoping to enter more advanced technical occupations, there should be courses of college level in college algebra, coordinate geometry, elements of calculus, and general physics as applied in electronics, radio, aeronautics and communication services.

Chemistry

Because chemistry is a highly specialized subject and its job opportunities are pretty localized, it seems that the first step would be to make a survey of the local community to determine how many chemists could be placed in jobs. The types of opportunities available should be carefully noted and placed in proper categories, such as laboratory technicians, routine analysts, process control technicians, metallurgists, research workers, and the like. Returning service men and women should not be encouraged to take training in chemistry unless there is a likelihood that the training will lead to successful employment.

Returning men and women who have had professional training in chemistry, either in pre-war college experience or in the war-time service should be encouraged to continue their training in a regularly organized curriculum of chemistry or chemical engineering, if they desire to qualify as professional chemists. Such a program could be carried out under a system of intensified effort, but it does not seem desirable to employ a system of speed-up or short cuts.

Persons who desire a briefer or less exacting program could be fitted for many laboratory positions as technicians, analysts, or in process control, by special plans based on the background of the candidate and the type of prospective employment, which would allow the omission of many of the usual routine courses of instruction. Such a candidate should understand that his chances for advancement in a purely chemical vocation would not be of the best; but for the purpose of preparing quickly for a job it would be worth serious consideration, especially when the advantages of technical institutes were available locally.

The curriculum of the technical institute will depend largely upon the vocational opportunities in the locality in which the institute is situated. In large centers where the industries are diversified, courses may be both general and specialized. In a locality where one or two industries dominate the field, courses will have to be worked out which train for the industry in particular.

In general, however, technical institutes or other below-college level institutions might include such fundamental courses as principles of inorganic chemistry and basic organic chemistry, as well as courses designed to prepare chemical analysts and technicians (for local industries) metallurgists' helpers, inspectors, and courses for nurses, firemen and other special occupations. There may also be an interest in such courses as Elementary Chemistry for general education, Chemistry for Consumers, or Recent Advances and Trends in Chemistry.

Biology

With reference to training in biological subjects and agriculture, as this may be provided in technical institutes, junior colleges, or special day or night schools, the offerings should be relatively broad and provide a wider opportunity for training than is usually offered in high schools because of the advance in age, great variety of military experience and resulting maturity of outlook on the part of exservice trainees and of men and women returning to school from industry.

Courses in basic biology should be included because of the prominent place which technological vocations will have in the postwar civilian economy and because of the new developments in biological sciences as these relate to technology. Basic biology is important to agriculture as the latter deals with soils, crops, animal husbandry, and fermentology. Basic biology is also important in reference to medicine, personal hygiene, public health and general education; hence attention should be given to courses in general biology, zoology, botany, bacteriology, hygiene, and general and human physiology. While maintaining flexibility of instruction to insure early employment of the trainee, adequate provision should be made for laboratory experience in basic courses in biology. Careful scrutiny should be given to the objectives and principles of the courses included with the view to obtaining a sound program of biological science in the postwar training program for exservice men and women.

CORRECTING WATCH TIME BY WATCH VIBRATIONS

E. M. TINGLEY
221 N. Cuyler Ave., Oak Park, Illinois

A good watch may be made to run faster or slower by balancing it, face horizontal, on a bit of rubber about 1/32-inch thick cut from a live elastic rubber band.

A button of rubber $\frac{1}{8}$-inch round or square will cause the watch to gain ten to twenty seconds over night or in about ten hours. It may require several attempts to balance the watch horizontally on such a small button. The guard or chain must be removed. The oscillations or shimmy of the whole watch due to the reactions of its balance wheel should be plainly visible.

A similar rubber support about 3/16-inch square will cause the watch to lose about six seconds in ten hours.

It is interesting to view very small oscillations with a microscope using a magnification of 30 to 60 diameters. Place the watch with its rubber support on a glass slide for convenience in centering it on the microscope stage and use the fine scratches on the pendant as targets. Also watch oscillations may be projected greatly magnified on a screen with the familiar laboratory mirror and lamp.

Using the cut-and-try method with rubber supports a good watch may be maintained within ten seconds of correct time indefinitely by repeating the correcting operations occasionally as required, without opening the case.

Opening the watch case for the usual methods of correcting watch time is objectionable as dust and moisture may be admitted. It is also difficult to adjust the registration between the second hand and the minute hand.

There are at least 25 other ways mechanical, with their variations, of allowing a whole watch to oscillate so as to change its time rate but the rubber button support is one of the simplest. Possibly some of the other ways could be produced in convenient and commercial form.

One bifilar pendulum suspension of fine threads (56-3 nylon), when properly tuned, allows about fifteen degrees arc of vibration in the plane of the dial, an astonishing amount.

All the above applies to a 16-size lever set watch of railway quality. It is probable that like performances may be obtained

with 12 or 18-size watches by trial, but probably not with very small watches.

After experimenting with various methods of free oscillations one becomes suspicious that the fabric or the surface on which a watch lies at night, or the hook on which it hangs, might affect its timekeeping.

The action of a watch on a support permitting oscillations due to the reaction of its balance wheel is well known to horologists. Oscillations of a whole watch are often observed when the watch hangs on a simple hook. This performance is known in mechanics as the action of two coupled oscillatory bodies and it is quite difficult of mathematical analysis. It is often illustrated experimentally in physics by two coupled pendulums.

The NBC precision time signals, and the continuous time signals on 2.5, 5, 10, and 15 megacycles, from the Bureau of Standards, afford reliable standards for maintaining correct watch time.

PRE-SPUN TIRES ON PLANES GIVE EXTRA LANDINGS

Airplane tires that start spinning before they touch ground are proving able to make extra landings and smoother ones, Henry F. Schippel of the B. F. Goodrich company, inventor of the "self-starting" plane tire told the national aeronautic meeting of the Society of Automotive Engineers.

At a time when the importance of prolonging the life of plane tires is heightened by the shortage of natural rubber and by gruelling landing conditions encountered by military flyers in foreign lands, the results of tests of this pre-rotation on planes in service, the speaker said, are "particularly gratifying." He added:

"The tests indicate that pre-landing rotation of wheels not only reduces the dragging of tires at moment of landing due to inertia, but also decreases tire damage from cuts sustained during ground contact, breakage of wheels, and damage to landing gear."

Through the Goodrich device, which consists of an arrangement of nine flexible vanes built into the sidewalls of the tires so as to catch the air with windmill effect when the landing bear is lowered, a pre-rotation of 80 per cent has been accomplished on DC-3 airplanes, Schippel said. That means, he said, that the wheel is rolling 80 per cent as fast as it would be if completely "free-wheeling" along the ground.

With the aid of charts and illustrations, the inventor described tests and calculations which indicate that a pre-rotation of 75 per cent causes a 50 per cent reduction in the wear on treads due to the "landing slide," in addition to reducing cuts and damage to tires, wheels and gear from landing shock.

An outstanding feature of the pre-rotation device described, Schippel said, is that the vanes "catch" the wind and are pulled out only on the lower half of each rotation of the wheel, and spring back flush with the sidewall during the upper half of the cycle.

COMBINATION NEWCOMB ENGINE AND HYDRAULIC ELEVATOR

BENJAMIN H. STASCH
Corning, New York

(EDITOR'S NOTE: Do not be disturbed by this formidable heading. The title merely indicates that a few changes make the apparatus usable for two demonstrations. As Mr. Stasch began to describe his hydraulic elevator, he realized its possibilities as a Newcomb's Engine. These "brainstorms" of Mr. Stasch make him outstanding; we are fortunate that he has consented to describe for us some of his ingenious pieces of homemade equipment. . . . W. A. T.)

An auto pump is the best possible start for this apparatus, providing, as it does, the material for the cylinder. Lacking a pump, one may use brass or bronze water pipe, lavatory waste pipe or smooth seamless steel tubing. Whatever material is used, it should be an inch or more in diameter and free from dents.

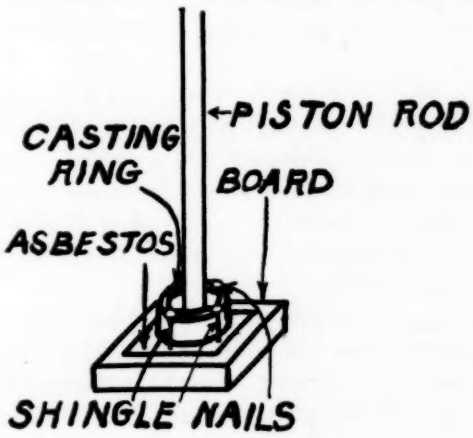

FIG. 1. Casting the piston.

The piston rod is made of steel rod 3/16″ or ¼″ in diameter. Brighten 1½″ of one end with a file, flux with zinc chloride and coat with solder.

The piston will be made of babbitt metal cast on the end of the piston rod. Drill in a board a hole of the same diameter as the rod and one-half inch deep. Stand the rod, soldered end down, in the hole. A flat sheet of asbestos paper laid on the board where the rod penetrates it will prevent the babbitt metal from burning the wood.

Saw from the pipe used for the cylinder a $\frac{3}{4}''$ length, to serve as a mold. Put it on the asbestos sheet with the steel rod carefully centered in it. Three shingle nails driven about the pipe so that their heads hook over the edge, will anchor the pipe.

Fill this piece of pipe with melted babbitt. Remove the shingle nails and the outer mold. If the mold does not slip off easily, saw just through the ring, after which it can be pried off.

The piston should now fit the cylinder. If it does not, sandpaper it carefully. Saw off the stub of the rod that protrudes through the piston.

Drill a hole near one end of the cylinder and solder a $\frac{1}{4}''$ tube into it. Drill two $\frac{1}{8}''$ holes in a flat of sheet metal, solder it to the inlet end of the cylinder and nail it to the crosspiece on the board upright. Oil the piston and cylinder copiously.

Two one gallon kerosene cans are the most practicable for the boiler and condenser. Syrup cans will do if they are reinforced by transverse pieces of heavy wire pushed through holes in opposite sides so that the protruding ends can be soldered to the can.

To operate, open the pinch clamp and boil about a cup of water in the boiler long enough so that the steam will drive the air our of the boiler, condenser and cylinder. Close the pinch clamp and pour cold water over the condenser. When the vacuum occurs, the rod jumps so quickly that it may be necessary to tie a piece of white paper to the rod to enable the pupils to see what has happened.

You must emphasize the point that Newcomb did not use a condenser separate from the boiler as Watt did later. He sprayed cold water into the cylinder, thereby greatly decreasing the engine's thermal efficiency. If you wish to reproduce Newcomb's set-up more closely, you may cut out the condenser and rig up a water injector. The author has poured cold water over the outside of the cylinder, but it is a messy job.

This set-up will baffle rather than enlighten some children, so that introductory operations may be necessary. Put a teaspoon of water into a large flask and insert a lighted splint. Boil the water and insert the splint. The steam has driven the air out. The pupils can see that a small amount of water makes a large amount of steam. Boil the water completely away, cork the flask and set it outdoors. When the steam condenses, the pupils can see that a large amount of steam becomes a small amount of water. Run a rubber tube from an exhaust barometer, which is

described in a previous number of this magazine,* to a glass nipple stuck into a one-hole stopper. Boil a little water in the flask, put in the stopper and pour cold water slowly over it over a catch basin. This procedure will also clarify the collapsing syrup can experiment.

To operate the set-up as a hydraulic elevator, disconnect the

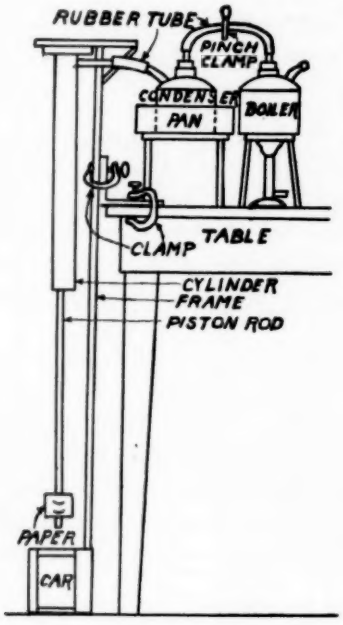

FIG. 2. Demonstrating Newcomb's engine.

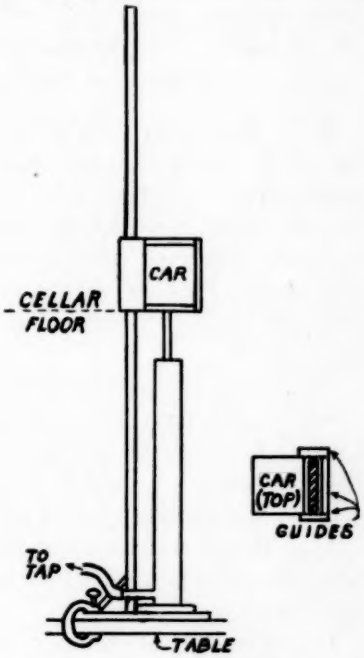

FIG. 3. Demonstrating the hydraulic elevator.

gallon cans, invert the apparatus and clamp it near your water tap. If the guides are a little loose, the car will ride on the piston rod. Connect the cylinder inlet tube to your tap and turn on the water. (If yours is a hose tap, ream a $\frac{1}{8}$" water nipple large enough to take a short piece of auto gas line, solder the junction, and solder the water nipple into an outside end hose connection. If it is the standard classroom tap, the hose connection can be screwed to a foot-long piece of garden hose slipped over the tap and fastened with a hose clamp. Few teachers can do water pressure experiments because most classroom taps are not made for

* Stasch, Benjamin H., "Exhaust Barometer in Air Pressure Demonstrations," SCHOOL SCIENCE AND MATHEMATICS, March 1944, p. 201.

hose connections.) To complete the picture, the car can be made to ride through two or three floors built into an orange crate around the elevator.

WORDS AND THINGS; PROLATE AND CURTATE CYCLOIDS

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In the December issue of SCHOOL SCIENCE AND MATHEMATICS, Mr. A. H. Beiler calls attention to the lack of uniformity in the terminology concerned with cycloids. He also lists some American and English works, denoting by *A* those in which a cycloid is called prolate or curtate according to whether it is the path of a point *P* lying within or without the circle which rolls (without sliding) along a fixed line; opposite convention is denoted by *B*.

As I too in the past have already taken up my position in the question and have adopted convention A (*Fano e Terracini: Lezioni di geometria analitica e proiettiva*, Torino 1930, 2nd ed. 1940) I venture to add a few remarks on the subject. In convention B a prolate cycloid is looped and in convention A loopless, so that for the sake of clarity I shall speak of looped and loopless cycloids until I give my reasons for justifying the terminology used.

It is a matter of common knowledge that to employ a word current in ordinary language in a mathematical theory presupposes a definition, or convention. It must be emphasized that such a convention implies to a considerable extent subjectivity and even arbitrariness. It implies subjectivity in so far as the adoption of that word originates in personal associations and arbitrariness. In some cases because the same word may be indifferently associated with a certain occurrence or again with the contrary one. As is well known, a typical example of this may be seen in the use of *left* and *right:* for instance a circular helix with vertical axis is called right or left according to whether it ascends towards the right or the left for an observer placed parallel to the axis; nevertheless for some authors the observer is placed within the helix and for others outside it; the two conventions are contradictory (so that for instance right helices of the work of Fano and myself already mentioned

coincide with left helices of the well known *Lezioni di geometria descrittiva* by the same Fano). Likewise two lines r, s neither intersecting nor orthogonal, constitute a right or left pair according to whether an observer placed (in whatever sense) along r sees a point moving downwards as moving towards the right or the left; but if "upwards" is substituted for "downwards" right pairs become left pairs and *vice versa*.

But let us return to cycloids. The adoption of the adjectives "prolate" and "curtate" may be explained on the basis of the following points of view:

1. An ordinary cycloid becomes loopless if it is submitted to a suitable deformation which produces a stretching out in the sense of its "length." It is obvious to assume the sense in which the cycloid extends indefinitely to be lengthwise, so that this point of view leads us to adopt convention A.

2. If the point describing the cycloid belongs to a rolling circumference which slides uniformly forwards or backwards, the cycloid is respectively loopless or looped. Also according to this point of view (which constitutes in fact a concrete determination of 2) the loopless cycloid is associated with the notion of stretching out. We have thus a further reason for adopting A.

3. The shadow on a horizontal plane of a circular helix with vertical axis, lit by parallel rays of light, is a cycloid which may be ordinary, loopless or looped according to whether the luminous rays are equally, less or more inclined than the helix. This also is a good reason for adopting convention A. It seems suitable to call prolate the loopless cycloid: *the further the sun goes down, the longer the shadows become.*

4. Referring to rolling without sliding when the point P passes from a position on the circumference to another in which its distance b from the center becomes greater than the radius b, the ordinary cycloid is transformed into a looped cycloid. Therefore one would feel induced to associate the concept of an extension with the concept of the looped cycloid ($b=a$ becomes $b>a$) namely to adopt convention B. Nevertheless, what in this case is stretched out, is not the cycloid but the distance b, whereas the adjective "prolate" does not apply to that distance, but to the cycloid. Therefore the point of view (4) does not seem to offer a sufficiently convincing reason for adopting B instead of A.

I believe that the ensemble of the various points of view just mentioned lead to a preference for convention A.

The opposite meaning of the term "prolated cycloid" as employed in (4) with regard to 1, 2, 3 may be considered as an example of the following processes, which are both well known in philology:

a. A prolate cycloid of convention A becomes curtate for those who have 4 in their mind: i.e. *different individuals apply different terms to the same object* for the cause that an individual has misunderstood the use of the term employed by another. For instance a high peak of the Pedmontese Alps (Italy) was called in the local dialect *Grant Parei = Great Wall;* later on some unknown cartographer, having misunderstood the reason for the denomination changed it into *Gran Paradiso = Great Paradise* which has remained the official name ever since.

b. The same term "Prolate cycloid" following the two different conventions A and B, is applied to two different objects; i.e. *application of the same term by different individuals to different objects.* For instance the Latin adjective *largus = abundant* which has retained approximatively the original meaning in the English *large* has passed into most Romance languages with other meanings one the direct opposite of the other. In Spanish and Portuguese it has become *largo = long*, in Italian *largo* and in French *large* with the prevailing meaning of *broad.*

I should also like to add that among the Italian works which I am able to consult here convention A is adopted by F. Enriques (*Lezioni di geometria descrittiva*) and G. Loria (*Curve sghembe speciali*, vol. II, p. 131) as well as by Fano-Terracini and Fano in the works already mentioned. The convention B is adopted by A. Comessatti (*Lezioni di geometria analytica e proiettiva*) and D. Tessari (*Applicazioni della geometria descrittiva, La teoria delle ombre e del chiaroscuro*). Sometimes one remarks a certain confusion in the use made by the same author: for instance in the article *Curve e superficie secipali* of the *Enciclopedia delle matematiche elementari* G. Loria adopts convention A in the text and convention B in the corresponding figures.

Among some particularly well known works I quote the *Encyklopädie der mathematischen Wissenschaften*, article *Besondere trascendente Kurven* III D 4 by G. Scheffers, p. 195, ref. 20, where it would appear that convention B is adopted (though this is not altogether clear) and Pascal's *Repertorium der höheren Geometrie*, Chapt. XXII by H. Wieleitner, where the loopless cycloid is called *gestreckt = prolate*, following convention A. On the

contrary, Salmon adopts convention B (I could consult only the French edition: *Traité de géométrie analytique; courbes planes*, 2.ème tirage, 1903).

It would be worth while for some one who could consult previous works (which it is impossible for me to do here) to examine the original sense of the terms under discussion. For example with regard to the generation of cycloids as shadows according to 3 the *Lettres sur l'architecture* by Guillery (Bruxelles 1847) and the *Memoirs de Géometrié descriptive* by Th. Olivier might be consulted. In the latter work one will certainly find a reference to the fact that in 1847 Olivier communicated to the Société philomatique the theorem alluded to, on the part of a friend. I am indebted for these indications to Loria's works mentioned above.

Summing up, Mr. Beiler asks if a choice between A and B has to be put to the vote. For my part, judging the question from an intrinsic point of view without considering the results of a more detailed historical investigation, I should again give my vote for A.

STANFORD UNIVERSITY GRADES IN WARTIME

Except in the cases of a few individual students, the impact of war on American college youth has not caused any appreciable change in Stanford students, scholarship averages, according to a study of grade averages for the past 24 years recently completed at Stanford under the direction of Registrar J. P. Mitchell.

In spite of students increasing their course load beyond the usual 15 units, and attending classes throughout the year without the three months summer vacation, grade averages for both men and women increased slightly after Pearl Harbor.

Evidence of possible influence of the war in development of certain extremes in scholastic achievement was seen in increase in 1942–43 over the pre-war year of 1938–39 of 1 per cent in scholastic deficiencies at the lower extreme, and an increase of 3 per cent in the number of students at the top who achieved a B average grade or better.

One explanation offered for the students' apparent ability to carry more courses and still do better work was that the war has made most students more serious, while only a few students have relaxed into an "eat, drink, and be merry" attitude.

FREE PAMPHLETS ON VOCATIONAL GUIDANCE

Librarians, counselors, and others interested in vocational guidance will find useful material in the new 1944 list of "26 Free Pamphlets on 16 Occupations," including the names and addresses of the publishers from whom the pamphlets may be obtained. To get this list send 25¢ to Occupational Index, Inc., New York University, New York 3, N. Y.

POPULAR MISCONCEPTIONS OF VARIETY ORIGINS

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The mother of the present author tells of the "love apple"; a variety of tomato of the size of the end of one's finger, grown as an ornamental plant in her childhood. Indeed this was the only tomato known in her neighborhood and it was so little appreciated that her parents gravely cautioned her not to eat it, for it might by poisonous.

A rather common misconception has arisen that our widely differing varieties of this fruit have developed from the "love apple" during the lifetime of a woman who still is living. This idea is dispelled in the *Yearbook, 1937* of the U. S. Department of Agriculture, which is composed entirely of histories of plant and animal breeding. Boswell, page 176, states that records date back almost 400 years and trace the tomato to Mexico. "The earliest references in the literature describe essentially the same forms that are grown today." Early in the sixteenth century it was introduced into Europe, and in the seventeenth century was grown in England for ornament only, although known to have been eaten elsewhere. The present varieties of large tomatoes doubtless were imported from the tropical home later than the "love apple" instead of being developed from that tiny ornamental type.

A similar misconception obtains concerning the strawberry, being found in books and even in a recent chart put out by a scientific supply company noted for its accuracy. In *Self Knowledge*, pages 392 and 393, Shannon pictures our wild strawberry with the legend, "Nature gave us this," then a cultivated strawberry with the legend, "Good heredity and environment produced this." The implication is strong that the small, soft, pale scarlet, acid *Fragaria virginiana* is the sole ancestor of our cultivated varieties; that the added size, color, and firmness have been acquired through man's selection and improved environment.

It is true that *F. virginiana* is one ancestor, but another is *Fragaria chiloensis*, a large, firm, sub-acid strawberry of western South America and extending as far north as the coast of Alaska. Popenoe gives a very interesting and well illustrated description

in the *Journal of Heredity* of the large plantations of this fruit. A missionary from South America told the present author that some of the berries, one and one-half inches in diameter, are so solid and so lacking in acid that they do not tempt the appetite until cooked. Popenoe states that the species was taken to Europe in 1712, where large berries had not been known, and crosses were made not only with the tiny European berries but also with our own *F. virginiana*. A later history is related by Darrow in the *Dept. of Ag. Yearbook, 1937*. He refers to the work of A. F. Etter who developed and introduced fifty or more varieties of strawberry, most of which were crosses of *F. chiloensis* with cultivated varieties.

It seems clear that man's cultivation and selection of strawberries in this country have developed nothing new; the new characters having been imported, and added by crossing.

A close parallel is the genetic history of our lard type hog, comprising the very similar breeds Duroc Jersey, Chester White, Poland China, and others. Persons who think this descended from the wild boar of northern Europe marvel at the great changes seemingly produced by selection; for the wild boar has a very sharp back, coarse bristles, a long snout, and can not be fattened until it is mature. However, the hog of China has contributed as much if not more germplasm than the European ancestor.

In the 1912 report of the Smithsonian Institution, Keller states; "As for our pigs, the investigations of Rötimeyer and Nathusius have proved that even in prehistoric times Asiatic blood reached Europe. The banded pig, *Sus vittatus*, distributed over southeast Asia is the wild pig from which the domesticated Asiatic pig has been developed. All doubts about this are dispelled by the anatomic facts in the case. Southern Europe has always kept these pigs to the exclusion of all others."

Pictures of these hogs taken in China, published in the *Journal of Heredity*, Vol. XI, p. 116, and reproduced in *Fundamentals of Zoology* by Tinkle, reveal a great likeness to the American lard type, the chief differences being a large belly and a low back. In the legend the author states, "It is this hog that was largely used in the early development of the European breeds." Without a legend one would think them to be Spotted Poland Chinas. A missionary described to the present writer the wild hogs in the Chinese mountains, which he hunted to provide meat for his family, doing this several years. All that he saw

were in good flesh regardless of their age, not lean and sharp-backed like the northern European hog. Thus the tendency to put on flesh at any age, so characteristic of the lard type hog, is traced directly to one of its ancestors, and it can not be claimed that it was developed by selection or improved feeding.

Some of our most beautiful flowers have been imported directly from wild areas; as for instance the regal lily from western China in 1904, reported in *U.S.D.A. Yearbook, 1937*.

According to Merle T. Jenkins, "The corn plant of today is little different from the plant Columbus found when he discovered this country." Collins in the *Journal of Heredity* amply corroborates this statement by a description and photographs of a fossil ear of corn, found by F. H. Knowlton in South America. "Dr. Knowlton is confident that, although the specimen may not be assigned to its exact geological period, it is an undoubted fossil. Yet the type it represents is domesticated maize essentially like the varieties still being grown in Peru and Bolivia." Kempton also has published pictures of prehistoric Aztec pottery in which corn is part of the decoration of the vase. The ears represented appear to be facsimiles of some of our modern varieties.

It is true that a character dependent upon multiple genes can be increased or accentuated by selection within certain limits. Examples of such inheritance include sugar content in beets, milk secretion in cows, egg production by hens, and weight of farm animals. Steady progress has been made by selecting hens that have more genes for high egg production. When the improvement due to selection slows down as it will, it may be revived somewhat by making all the matings that are possible in the flock, then selecting the best of the progeny. While the birds are alike in production they may be unlike in genes, and transgressive variation will give greater extremes of production. By following these methods the limit of effective selection is reached in time just as Johannsen pointed out in his work on beans, for the birds will become alike not only in production but also in genes. Then the only method of further progress is importation of birds with better germplasm. There are flocks and herds in this country that are approaching and may have reached this condition. (Live stock breeding at the crossroads; *U.S.D.A. Yearbook, 1936*).

The possibility of polyploidy does not alter the above statement for the following reasons. (1) Induced polyploidy is prac-

tically unknown in animals. (2) The work of Richaria and Howard, reinvestigating the most famous plant tetraploid, the cross of *Raphanus sativus* with *Brassica oleracea*, produced results different from those of the original investigator, Karpenchko. This has shown the need for further study of other polyploids. While it is true that a mutation might occur, no mutation has been observed that increases production. Greater egg production due to improved feed does not affect the next generation of layers.

Thus the method that actually has given us our varieties is importation, often coupled with crossing, using selection as a supplement, but not selection alone. Likewise improved environment has done little to change varieties in the long run, since the environment influences only the present generation and its results are not cumulative.

All of the above is but the application of principles clearly stated by our best modern geneticists. Morgan, in *Evolution and Genetics*, discusses principles of selection, and states, p. 126, "If the taller men of a community are selected, *the average* of their offspring will be taller than the average of the former population. . . . More tall men may be produced by selection of this kind, but the tallest men are not necessarily any taller than the tallest in the original population. Selection, then, has not produced anything new, but only more of certain kinds of individuals." Thus, while genes may be sorted out or recombined, they can not be synthesized but must be found in nature.

Teachers of science are in a position to make known to the common people the great recent advances in genetics, allaying false expectations and increasing their progress in practical breeding.

LITERATURE CITED

Boswell, Tomato improvement. U. S. Dept. Agriculture *Yearbook 1937*, p. 176.

Collings, G. N., Fossil ear of maize. *Jour. of Heredity*, Vol. X, p. 170, 1919.

Darrow, Geo. M., Strawberry improvement. U. S. Dept. Agr. *Yearbook, 1937*, p. 445.

Howard, H. W., Fertility of amphidiploids from the cross *Raphanus sativus* × *Brassica oleracea*. *Jour. of Genetics* 16: 239–273.

Jenkins, Merle T., Corn improvement. U. S. Dept. Agr. *Yearbook, 1936*, p. 460.

Johannsen, W., Über Erblichkeit in Populationen und in reinen Linien. Jena (1903).

Keller, C., Derivation of European domestic animals. Report Smithsonian Inst., 1912, p. 487.

Kempton, Picture of prehistoric maize vas. U. S. Dept. Agr. *Yearbook, 1936*, p. 457.
Levine, C. O., Swine, sheep and goats in the orient. *Jour. of Hered.*, Vol. XI, p. 116, 1920.
Morgan, Thomas H., *Evolution and genetics.* Princeton Univ. Press.
Popenoe, W., The frutilla or Chilean strawberry. *Jour. of Hered.*, Vol. XII, p. 457, 1921.
Richaria, R. H., Cytological investigation of *Raphanus sativus, Brassica cleracea,* and their F_1 and F_2 hybrids. *Journ. Genet.* 34: 19–44, 1937.
Shannon, T. W., *Self knowledge.* Cincinnati, S. A. Mullikin Co.
Tinkle, Wm. J., *Fundamentals of zoology.* P. 435 ff.; Grand Rapids, Zondervan Publ. House, 1939.

A BRIEF COLLEGE COURSE IN SCIENCE FOR ELEMENTARY TEACHERS

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A science course which is designed to prepare students to teach 7th and 8th grade science according to the course of study outlined by the state department of education is given in the two year curriculum at Mankato State Teachers College. A judicious use of time is necessary since this 4 quarter hour course is the only science work provided in the curriculum. A study has been made to determine how to use the time most effectively.

The course content of the 7th and 8th grade science as recommended by the department of education is largely physical science. Approximately $\frac{2}{3}$ of the syllabus deals with physical science and $\frac{1}{3}$ is evenly divided between biological science and topics relating to health and first aid. A study of the state board examinations in the 8th grade shows an increasing emphasis on physical science principles.

On the basis of these findings the course in science for prospective teachers in rural schools should emphasize physical science. The topics on health and first aid which are generally included in the 7th and 8th grade science can be omitted because students take a special course in this work.

The first part of the course is divided into units on astronomy, meteorology, geology, electricity and magnetism, sound and light, and plants and animals associated with gardening and conservation. To enable the students to obtain a background to teach the subject matter associated with such subjects as air, water, fire and energy, four weeks is given to a study of the

physics and chemistry of the structure of matter, gases, solids and liquids. One week is used in the study of some of the new developments in science: the airplane, plastics, war gases, synthetics and vitamins. Required reading in the course is selected from several textbooks and periodicals.[1]

Simple experiments using homemade apparatus are performed by the students. Lecture work is supplemented with film strips, movies and field trips. Students examine and make reports on 10 or 12 of the common grade texts in 7th and 8th grade science and study some of the current literature on science teaching in the elementary level.

The ultimate goal in this brief course in science is twofold: to stimulate student interest in science and to suggest teaching methods in the presentation of subject matter.

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[1] Craig, Gerald S. *Science for the Elementary-School Teacher*. Ginn and Co. 1940.

Cable, Emmett James, Getchell, Robert Ward, Kadesch, William Henry. *The Physical Sciences*. Prentice-Hall. 1940.

McCorkle, Paul. *Survey of Physical Science for College Students*. P. Blakiston's Son and Co., Inc. 1938.

Science of Pre-Flight Aeronautics for High Schools. The Macmillan Co. 1942.

The Conservation Volunteer, Official Bulletin of The Minnesota Department of Conservation.

NATIONAL CHEMICAL SHOW IN CHICAGO

Sponsored by the Chicago Section of the American Chemical Society, the third National Chemical Exposition will be held Nov. 15 through 19, 1944 at the Chicago Coliseum, it is announced by M. H. Arveson, Chairman of the Exposition Committee.

The two preceding exhibitions under the same auspices, the first in 1940 and the second in 1942, were held in Chicago Loop hotels. It is reported that a survey of prospective exhibitors for the 1944 show indicated that infinitely more display space would have to be provided than could be made available in any Loop location.

Accordingly the Committee adopted the alternative of leasing the nearest available exhibition building to the Loop, the historic Coliseum, at 15th Street and Wabash Avenue. Scene of numerous national political conventions, trade shows, circuses and other major events over a period of years, the structure recently passed into new ownership. It has been completely rehabilitated and has excellent transportation facilities.

Marcus W. Hinson, Manager of the first two national shows, will direct the November exposition. He states that more than 50,000 square feet of floor space will be made available, all of which is on one floor.

WATER RESISTANT CLOTH

Fire hose, canvas and raincoats are now being made of a new cotton fiber which, when moistened, swells enough to block up the interstices in fabrics made from it. The cloth becomes water-resistant and water-repellent.

APPROXIMATIONS IN PHYSICS TEACHING

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Physics has often been called an exact science and it appears that at times book publishers, and perhaps even we as teachers, may have been bending over backward in our attempts to be exact. Possibly we have overestimated the value of such exactness in developing accurate concepts in the minds of adolescent pupils. Might it not be that such attempts have sometimes actually resulted in time losses and in a discouraging loss of interest?

Let us note a few of these supposedly exact figures given in some of these ultra modern texts: 1 inch equals 2.54 centimeters. 1 kilogram equals 2.2046 pounds. 1 yard equals 3600/3937 of a meter. Water 1 foot deep gives a pressure of .433 pound per square inch. The atmospheric pressure is 14.7 pounds per square inch. The value of acceleration due to gravity is 32.16 feet per sec. per sec. 1 liter of air weighs 1.393 grams.

None of the school rulers or graduates or balances are calibrated to read beyond the first decimal, so it is only with a vernier or micrometer that measurements of a second decimal could be made directly, and these are seldom used. Why not say 1 inch equals 2.5 centimeters; 1 kilogram equals 2.2 pounds: 1 meter equals $39\frac{3}{8}$ inches: 1 foot of water gives a pressure of .5 pound: The atmospheric pressure is 15 pounds per square inch: 1 liter of air weighs 1.5 grams?

After all who has the more exact concept of the pressure of a 50 foot head of water, the pupil who has used the .433 and in figuring has mistaken his decimal point and obtained an answer of 216.5 pounds or the pupil who writes from inspection that one half of 50 is 25 pounds? From what we learn from reports of examinations given a year later, nobody remembers the .433 anyway, and there might be a chance that a few would remember the half pound.

We used to make it very clear that sound travels 1087 feet per second but the most of us have been rounding this off to 1090 or 1100 ft. to our own and the pupil's satisfaction. We wonder why the heat of fusion and the heat of vaporization of water are even 80 and 540.

After all our own mathematical experiences it might seem like

carrying this idea of approximation too far to suggest that the value of Pi be called 3.1 or even 3, yet it would make very little difference in calculating the contents of a cylinder, with the dimensions given in small numbers, whether one called Pi 3.1416 3.1, or 3, but it would make a great difference in the time taken to compute the volume.

In general it would seem of more value to the pupil to approximate values so he could follow through a problem quickly and sense the correctness of the answer, rather than taking so much time for the computing processes, with fractions so diverting his attention that he looses track of the thing he started out to find.

After all it is impressions and not facts we are stressing. Take for instance the legal definition of the ampere. If a pupil learned this so he could say it correctly he might still not have as good a concept of the value of the ampere as would some other pupil who had not learned it, but who had learned that a 60 watt lamp carried a half ampere and that a flatiron carried 5 amperes.

One thing puzzling to many of us physics teachers but which probably has a psychological explanation, is the fact that pupils who have studied algebra for a full year and who have had much drill in clearing fairly complex equations of fractions and in finding the value of X, are then unable to find the value of X in a simple equation like $\frac{1}{4}$ plus $\frac{1}{6}$ equals $1/X$—not simply individual pupils, but whole classes. And then taking such simple processes as adding one and a half, two, and seven tenths; a problem the average grade school kid of 12 years could quickly solve, we find dozens of physics pupils who find difficulty in adding these correctly.

Such being the working of the adolescent mind, the fewer of these mathematical processes the physics teacher is forced to review and the less diversion from the problem in hand, the more concentrated may be the thought on the physical concept.

One of our thoughtful teachers, after long experience as a teacher of physics classes, once suggested the wisdom of selecting the numbers in physics problems so that the answers would come out even. A group of our teachers once further advised avoiding the use of problems involving the area of a circle or the volume of a sphere. A college professor once offered this bit of fatherly advice "Don't load the gun with too big shot. Remember much of the game you are after is just sparrows."

As a matter of fact, outside of percentages, the average person

seldom uses fractions. Occasionally he may use the half, more rarely the quarter, but seldom the eighth, tenth, or sixteenth. With money it seems as though pupils are thinking of the half dollar, quarter dollar, and dime, more as multiples of the cent than as fractions of the dollar.

The common dimensions of rugs, of shades, of wall paper, height of tables and chairs, and even the sizes of our clothing, are usually given in whole units. So also are the lengths and widths of lumber, the sizes of windows and doors, and even the size of glass. If these do involve fractions they are rarely smaller than the half.

Even in the case of the automobile which every one understands is made with a high degree of precision, outside of the workmen in the factory, few persons have occasion to use fractions other than the half with reference to it. The diameter of the cylinder may be given with a fraction, but the length of stroke, wheel base, width of tread, length of body, and often the size of tire, are given in whole units.

The time is past when teachers may justify the assignment of a difficult problem mainly on the ground that it gives a mathematical review, or is a preliminary training for college work, so why not drop the fractions, round off the numbers, and give the kids a break?

POSTWAR JOBS IN OCCUPATIONAL THERAPY

Librarians, counselors, deans, teachers, students, parents, returning soldiers, ex-war workers, and others who want to know about postwar employment prospects in a growing profession, will find interesting facts in an 8 page folder on *Occupational Therapy* by Borghild Hansen, just published by Occupational Index, Inc. at New York University, New York 3, N. Y. Single copies are 25¢, cash with order.

This is the fifth in a new series of *Occupational Abstracts* covering occupations in which postwar employment prospects are favorable. Each abstract covers the nature of the work, abilities and training required, earnings, methods of entrance and advancement, geographical distribution of employment, postwar prospects, advantages and disadvantages, sources of further information, and best references for additional reading.

BULLET-SEALING RUBBER FOR PLANES AND TANKS

Modified rubber recently developed, mixed in small quantites with large quantities of synthetic rubber, gives a material satisfactory for bullet-sealing gasoline and oil tanks in airplanes. The mixture has the necessary quality of cohesion or tackiness.

THE EVOLUTION OF A SPECTROSCOPE

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One thing follows from another. It started with aquaria made by using two pieces of plate glass for front and back, and heavy woven wire for the bottom and ends upon which pure cement was plastered to a thickness of one-eighth to one-quarter of an inch. The cement must not be permitted to dry while it is setting or it will crack. Within a few hours after plastering the aquarium must have water in it. Setting speed is faster if waterglass is painted over the partly set cement, and the cement is more waterproof.

With this technique developed, liquid prisms can easily be made. My first consisted of two pieces of plate glass about 4″×8″ cemented into wire and cement ends to form a V hog trough, the bottom of which is made waterproof with cement. The angle of the V is about 70°. Angles up to 90° can be used. An angle of 60° is not enough to give a good dispersion with water.

This prism has been on my laboratory window sill for two years. Every sunny morning I have a beautiful spectrum first on the ceiling and then as the sun rises curving down along the wall. My pupils sometimes plot its path across the blackboard as it moves.

When the sun first rises there is no blue and violet. As it rises first the blue and then the violet appears.

Lime dissolves out of the cement and keeps forming on the glass. This is easily removed with hydrochloric acid. If the water is made acid, its formation is stopped.

There was an interval of two years between this and the next improvement. I have wanted a spectroscope for at least seven years—not badly enough to buy one but enough to try making one. The usual glass prisms are worthless because they are neither made of good glass nor well polished. I recently bought a good spectroscope prism for seven dollars. This I mounted between two pieces of tempered presdwood, considerably larger than the prism, by sticking the pieces on with pitch (rosin and turpentine). This protects the very fine optical surfaces.

If a narrow slit of light, such as between the shade and the window frame, is examined with this prism a very nice solar spectrum is seen showing some of the wider dark lines. The

further the prism is from the slit, the better the results. Observing this I cut a slit in the metal end of a cardboard mailing tube and soldered two razor blades over this in such a way as to make a very straight and perfect slit wide enough to admit several sheets of paper. When the prism is held to the tube at the opposite end from the slit, a very gratifying solar spectrum is observed when the tube is pointed toward daylight. Many dark lines are easily seen.

When this equipment is held in clamps and a Bunsen flame is placed near the slit and colored with suitable salts, beautiful spectra can be seen through it. A neon glow lamp also is very fine. The lines are widely separated.

I have yet to make a lens system that will make this a real spectroscope.

The excitement of this small success broke a dam, and another idea crashed through.

I held three microscope slides together with two rubber bands so that they made a very perfect equilateral triangular prism. Using a small paint brush and a pinch of wet cement I painted the edges with cement being careful not to go beyond the edges. Next, the edges were painted with thick waterglass and again with cement. The edges were kept wet for an hour using the little brush. After the rubber bands were removed it was necessary to touch up the unpainted places where they were. Then the prism was placed on a little glass base and fastened there by the same cement-waterglass technique. Within another hour, the prism held water; the next day it was well set.

With this prism the refractive indices of first water, then alcohol, then ether, and finally carbon disulfide can be determined by the familiar pin-sighting technique. The advantage of using these liquids in the above order is that the alcohol washes out the water and the ether washes out the alcohol and itself evaporates quickly leaving the prism clean and dry for the carbon disulfide. Absolute methyl is as good as ethyl alcohol.

The cement is porous to carbon disulfide. In the course of a day an inch of the liquid in the prism will completely evaporate even with a cover glass over it. The smell near the prism is almost as loud as the posterior aspect of a well-known cat-sized animal. This condition is moderated by putting some lacquer (label varnish) in the bottom of the dry prism and running it up the inside of the three edges, being careful not to let it smear much of the glass surface.

Filled with water, this prism does not give a very good spectrum, but with carbon disulfide, it gives more dispersion than the good glass prism. Using the mailing tube and slit, the dark lines are even better separated in the solar spectrum than with the glass prism.

And now, having made a spectroscope, I look back over seven years of periodic blundering struggle with the problem and marvel that anyone could be so stupid as to take so long to arrive at something so ridiculously simple.

"MATHEMATICS—A CULTURAL SUBJECT"

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For non-mathematicians mathematics is a practical tool for finding answers to questions proposed by business men, scientists, and engineers. It is needless to say that professional mathematicians share this interest. In fact, a good part of the work of a mathematics teacher consists in giving service courses for students specializing in the different professions.

Interest in the applied side is further strengthened by the knowledge that much of the development of mathematics has come about in response to the need for solving practical problems. But although such problems constitute the soil in which mathematics has grown and will continue to grow, the subject has an inner core and an organic life of its own. As a constituent part of the latter, mathematics presents an esthetic and philosophical side which can be very challenging and stimulating to anyone who responds to it.

It happens unfortunately, however, that the technique of mathematics which has been elaborated over a period of many centuries proves difficult of acquisition on the part of most students. The result is that teachers are quite happy if they can give their charges an indifferent mastery of the mechanics of the subject. No time is left for gaining a real understanding of the subject matter, to say nothing of an appreciation of its cultural values.

As a matter of fact, teachers are frequently lacking in awareness of this type of value, because after all, they are merely students who have gone through precisely the same mechanical

régime. Teaching and learning are complementary parts of a cyclical process. If students do not have their eyes opened to a broader view of the subject, they are not likely to have it as teachers. To aid in remedying this situation is the purpose of the present discussion.

The conviction that the cultural values of mathematics are as various as life itself is easily gained if we realize that the origin of number ideas is in all probability contemporaneous with the beginnings of articulate sound and gesture.

An interesting confirmation of the important role which mathematics has played from the very dawn of civilization is furnished by the findings of archaeology. Clay tablets exhumed in ancient Babylonia reveal mathematics rendering valiant service to an early developed property instinct by providing numerical records of ownership in cattle and wives.

From this earliest period down to the present day, the development of mathematics has continued to be interwoven with the fabric of civilization serving as an essential tool in every form of exact thinking.

Of the many human values offered by mathematics we shall discuss only its cultural contribution, restricting this in turn to a consideration of mathematics from the fine-arts standpoint of beauty or esthetics.

The definition of esthetics, as appreciation of beauty is circular in that such a definition merely replaces one expression by another which is more familiar, perhaps, but just as little understood.

If we wish to resolve beauty into something tangible, we find that mathematics supplies the vocabulary in such terms as balance, symmetry, repetition and unity in variety. The possibility of a mathematical analysis of beauty in the fields of painting, sculpture and music is discussed in considerable detail in a recent book entitled *Aesthetic Measure* by the Harvard mathematician, Professor G. D. Birkhoff.

We shall confine ourselves, therefore, to citing instances of beauty in the content of mathematics itself. High school geometry offers numerous examples.

The straight lines and circles upon which geometry is based have individually and in combination a very considerable esthetic appeal. The straight line embodies unity in direction, while the circle pictures unity in distance.

With two lines we have immediately a much richer design. If

they are parallel, the unity in direction theme is strengthened by repetition. In addition there is a further unity with respect to the distance between the lines.

For non-parallel or intersecting lines, there is a divergence of direction and, therefore, a loss of esthetic value. But this is more than compensated for by the presence of a new element of unity in the equality of the pairs of opposite angles formed by the two lines.

If now, coming back to two parallel lines, we adjoin a third line which cuts obliquely across the parallels, we gain a figure which is still richer in possibilities. The eye perceives in a single flash of intuition that all the similarly situated angles are equal. Since the four angles at each intersection are equal, respectively this equality theme is given a four-fold repetition.

In like fashion angles which are similarly situated on either side of the oblique line are obviously equal. This fact adds a right and left symmetry to the figure which possesses, therefore, a comparatively high degree of beauty.

On the other hand, a triangle in which no two sides are equal, that is to say, a scalene (crooked) triangle, has little or no beauty until we discover that every triangle has the sum of its angles equal to two right angles. This example of unity in variety invests triangles as a group with a certain measure of beauty. The theorem that angles inscribed in a semicircle are right angles is of similar esthetic interest.

The esthetic appreciation which results from awareness of a unifying principle is typical of abstract or mathematical beauty. The appeal which this type of beauty makes to the mental eye compares very favorably with that which results from visual beauty. That this should be so is easily understood if we realize that a unity which is hidden and has to be diligently sought out is always more impressive than one of the more obvious sort.

As another instance of abstract mathematical beauty, taken from geometry, consider the well-known theorem of Pythagoras which asserts that the square upon the hypotenuse of a right triangle is equal to the sum of the squares upon the other two sides. The relation stated in this theorem presents little or no visual appeal. This is because the eye is unable to take in the fact that the hypotenuse square equals the sum of the other two.

The theorem is true, nevertheless, and it represents such a beautifully simple relation that thousands of minds have been

surprised and charmed by it. As evidence of this, we cite the several hundred proofs which have been devised for this theorem. One of the most elegant of these is due to the American President, James Garfield.

Illustrations of beauty in mathematics have so far been confined to geometry. Algebra has just as real an esthetic appeal, but its beauty is more abstract and, therefore, more typically mathematical. One example will have to suffice.

If we recall that the square of $(a+b)$ is equal to $a^2+2ab+b^2$, we note that the exponents of a go down systematically while those of b ascend. The numerical coefficients are 1, 2, 1. In like fashion the cube of $(a+b)$ is $a^3+3a^2b+3ab^2+b^3$, the coefficients being 1, 3, 3, 1.

The attractive symmetry in the coefficients could have been predicted from the fact that the role of a in this problem is precisely the same as that of b. It constitutes, therefore, an important check upon the correctness of the work.

We see in this example, therefore, an exception to the proverb which asserts that it is impossible to "have one's cake and eat it too." In the present instance it is plain that we can enjoy esthetic pleasure and at the same time have the use of it in practical considerations. As a matter of fact if a pedagogical remark may be permitted, the effective way to learn is the pleasant way It is obvious that, if a given fact is esthetically enjoyed and not merely apprehended, its retention in mind is made more secure. This, in turn, makes association with other factual impressions easier and facilitates the entire thinking process.

We shall conclude at this point by redefining esthetic appreciation as awareness of a unifying principle of symmetry, balance, or repetition, together with an emotional reaction of pleasure. With this definition as a criterion we have attempted to show that mathematics is comparable to the fine arts with respect to the opportunities which it affords for esthetic contemplation.

For those who wish a further acquaintance with mathematics as a cultural subject we cite the following books which have appeared recently:

Number by Tobias Dantzig, the Macmillan Press.
Aesthetic Measure by G. D. Birkhoff, Harvard Press.
Mathematics for the Million by Hogben.
Men of Mathematics by E. T. Bell, published by Schuster.
An Invitation to Mathematics by Arnold Dresden, Holt & Co.

RADIUM*

LUTHER S. H. GABLE
Radium Physicist and Industrial Engineer, Adventurers Club, Chicago, Illinois

I hold in my hand a rare element that may easily be the secret of life or quick dissolution and death, depending on the hands that hold it. It is *Radium.*

The observation and study of the spinthariscopic effect of the normal disintegration of radium, led to the identification of the *Electron.* The control of that electron led to the invention of one of the most amazing secret weapons of modern warfare, and will take its place some day in a post war world of electronics, to make our present electrical age seem like the horse and buggy days in comparison.

When radium is refined to a metallic state, it resembles polished silver. Forty-eight hours later, it has disintegrated and reverted to a white dust, which grows darker, to brown or purple in a matter of weeks. Even its containers of glass will change color and seem to be burned. For this reason, radium is never refined to a metallic state. The process of refractionating is stopped just short of purity and the result becomes a radium-barium-bromide (chloride, or nitrate as may be desired)

At this point the speaker passed a glass tube about 6 inches long and $\frac{1}{4}$ in. in diameter,—containing two small sealed tubes, each of which contained fine granular discolored salts (which he identified as radium-barium-bromide) to be passed to each person in the audience. After carefully explaining how it should be held, he assured all that since it was only a 10% radium salt (i.e. 10% radium and 90% barium), the danger of burn was negligible if no one held it too long. After making the rounds of all present it was returned to the speaker's lead case, with others which he also displayed by using forceps. One tube identified as 56% pure $RaBaCl_2$ and a physician's therapeutic needle, a 10 milligram radium needle.

The high cost of radium is due mostly to the difficulties of refining. There is still no good short-cut from the original methods used by Mme. Curie in picking better crystals from repeated evaporating steps. However the quality of the ore is important. All uranium ore contains radium, $3\frac{1}{2}$ particles of radium to every 10,000,000 particles of uranium. That is the natural-state equilibrium. 400 tons of Carnotite from Colorado were required from which to refine 1 gram of radium. In the Belgian Congo a

* Presented at the Physics Section of the Central Association of Science and Mathematics Teachers at Chicago, November 26, 1943.

radioactive area was found so rich that only 25 tons were required to produce 1 gram of radium, and it put the American Radium industry out of business. To-day at the Great Bear Radium Mines in the far north, has been found pitchblend so rich that 1 gram of radium has been produced from only six tons of this ore.

At this point the speaker passed a specimen of pitchblend to make the rounds from hand to hand thru the audience. The smooth, black, yellow-stained rock was no larger than a small pound cake, but weighed 16½ pounds.

This is probably the richest and largest specimen of radium-bearing pitchblend on exhibition anywhere. On my scientific expedition into the Arctic by auto and aeroplane in 1934 I picked up this rock on the shores of Lake Hardesty near the arctic circle. The invisible black-light rays which beam in every direction from that rock are easily penetrating your hands and bodies even as you handle it. Here is the proof of that incredible statement.

Exhibit of a radiograph showing two keys and 2 coins in black silhouette against a background of "light-struck" or fogged area.

This picture was "taken" in total darkness by the invisible rays of the very pitchblend you hold in your hands in a four hour exposure. The ore was suspended above a sensitive plate, wrapped in opaque paper, and upon which was placed the two keys and coins. The gamma ray from the radium content of the ore fogged the plate and made shadows of the metal. However, if left in expose position too long, the metal pieces also would be penetrated. On this rule of time and intensity, radioactive ores are frequently tested and values calculated.

When I open this lead tube containing radium salts, there is an immediate escape of radon gas which is being constantly generated by the radium, and which, oddly enough, also emits alpha, beta and gamma rays. It can be confined and used as radium is used but will dissipate rapidly; losing one-half its energy in 3.85 days and half the remainder in another 3.85 days, repeatedly depreciating to nil in about 30 days. The presence of this radon gas in certain springs renders them radioactive. However there is no radium in a Radium Spring. The active element remains in the earth. As the spring-water passes by, it picks up radon which charges the water with radioactivity. It flows out at the mouth of the spring, where it also charges the air. Folks go there and drink the water (and breathe the air)

and charge their bodies. Then the hotel charges the guest a plenty and every one is happy. Remember this. Small quantities of radium stimulate life. Only large quantities or long exposure cause disintegration or death.

At this point several large photographs were exhibited showing a surprising difference in the growth of plant life comparable with,—and without radium in the soil.

This radon can be impregnated into any potable solution. I can drink such charged solution safely (wherein no radium element exists in suspension) and afterwards, in a dark-room, exhale against a fluoroscopic screen and observe thousands of tiny sparks like miniature lightning or falling meteors, in great profusion. This phenomenon persists for six hours after imbibing.

This same free electron has been observed in the vital human organs. We will skip that physiological aspect and pass over to the radionic application of the electron. We will pass also the use of a radioactive coated cathode in a vacuum tube to facilitate the flow of electrons, and pass on quickly into electromagnetic radiations, induced and projected as a directional beam by a new type of radio wave generator.

You are aware that radio waves proceed in a straight plane, but that the earth is round. Fortunately there is a ceiling, the Kennelly-Heavyside layer. Audio frequency radio beams strike that layer and bounce back, reflected at an angle equal to the angle of incidence, back to the earth, up again and back again, until it will compass the earth.

Now a new short-wave beam has been developed which is not reflected by the Kennelly-Heavyside layer and, we will say for simplicity, it goes on through and out into infinity, unless—mark this carefully—something dense or opaque like metal, should be encountered out there. When this certain wave strikes such a movable object it is reflected back instantly and, being a directional beam, can be picked up again nearby the point of origin where it is recorded on an oscilloscopic eye. Here the position, speed and number of such interferences are instantly located on the x and y axes where speed and direction are calibrated with the ease of reading a watch dial. That amazing invention is one of the greatest achievements in the new science of electronics. Many claimants have clouded the origin of this most uncanny of modern miracles, and of course no one individual can be credited with this amazing invention which

gives us electronic eyes to "see" in the darkness over incredible distances.

In fact the real origin of "electronics" is a very interesting story. This penetrating eye can be called the child of cosmic rays. However the child was kidnapped from its discoverers by the Japanese. In fact I have it from no less an authority than Dr. Rabinoff that the first book to appear anywhere on electronics, was published by the Japanese in Japan. (An interesting story of how this was accomplished is here deleted for diplomatic expediency.)

The German scientists read, took heed and went to work. They thought they had a secret weapon with which to protect their cities. To-day the Americans not only produce better "electronic" devices but have learned how to foil the enemy's observations. It will be a good story for after the war. It is no secret to tell you that American "electronic devises" of secret air-borne type can pick out another plane in total darkness, know instantly if it is friend or enemy, and pounce upon its dark unseen shape in the clouds and destroy it. Captured German pilots were incredulous with fear. How could we see them in the dark? How did we know they were enemy planes? The Yanks and the RAF told them "We eat raw carrots for good eyesight."

The commercial and industrial application of our war time electronic devices will constitute a major edition to our post war civilization on a par with the advent of the telephone and the telegraph. In railway cabs the engineer will be able to see his signals through any sort of mist and fog; ships at sea need not collide in fog, nor strike an iceberg or a reef. Planes would not crash a mountain side since the image of the mass obstruction would be projected, located and avoided long before the otherwise inevitable disaster.

The speed with which these new inventions will be adopted, and by whom, will constitute the difference between world peace and a world holocaust.

A NEW ALUMINUM ALLOY

Lightweight automobiles, refrigerators, railroad cars and other equipment may be made in postwar days of a new aluminum alloy of remarkable strength and toughness now reserved for aircraft. It is tough enough to replace armor plate, and so strong that thinner sheets may be used successfully in airplanes.

TEACHER FAILURE IN SCIENCE TEACHING

TRAVER C. SUTTON
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The writer of this article has been interested in science teaching for many years. He has had a particular interest in the reasons why some science teachers are successful—and why some teachers fail.

If one were able to set up a definition for "science teacher failure," perhaps the teaching problem would be well in hand. Investigation shows that we do not know of any measure which would be generally accepted for this purpose. It has been suggested that perhaps one of the basic causes for failure is that we do not have more teachers who are interested in science teaching who are willing to admit there are failures and are willing to give conscientious thought to how they may improve the quality of their work. Human nature may itself may be one of the greatest causes of failure. Sometimes a good teacher is greatly handicapped by local conditions, by lack of facilities or the quality of the students.

As an instructor in the science department in one of the largest high schools in the midwest, the author of this article has had the opportunity to hear comments of many school administrators and teachers on the subject of teacher failure. Indeed, for several years now, it has been a common subject for discussion in many of our informal conferences.

To me it seems a very common sense theory that it is better to try to do something about a problem than to merely sit in on informal discussions—and just talk. Therefore a group of fifty high school principals were consulted—questions asked— in the preparing of the material for the first part of this article. The results of these conferences are given without an attempt to interpret—and without the imposing of the opinion of the writer. Summaries of the answers given by these fifty school administrators follow:

(1) One very honest administrator, holding a position in a city of 3000 population, informs us that most of his science teachers fail because they are not good football coaches. He claims that his town must have good football teams—and that the science teacher has to coach the teams—and win. If he fails to win games he is not a good science teacher.

(2) Another point, which was mentioned several times, was that most young science teachers lack a breadth of science subject understanding. They try to teach too thoroughly and too deeply some one science. They attempt to teach high school students in the terms of science specialization.

(3) Most science teachers tend to overemphasize the branch of science that is being given publicity at a particular time. Some are trying to teach metallurgy, some electronics, and some plastics before the beginning high school students have gained a knowledge of the fundamentals of chemistry or physics.

(4) The principal of one of the large technical schools feels that most of his science teachers have been very successful. Some have needed corrective suggestions but none have been failures. The only causes of criticism being in regard to the poor care given scientific equipment and laboratories. Attention was called to the fact that many science teachers do not know how to estimate and to order needed science supplies and equipment. This experienced administrator suggests that systematic courses for teachers might be developed as a means of solving this problem.

(5) Several principals feel that science teachers do not know how to direct and control laboratory work. They too often substitute the lecture-demonstration for student laboratory work. There is too great a tendency for the teacher to do all of the work—and for the student to watch and listen.

(6) There is a very general acceptance on the part of school administrators that very few science teachers really fail. When failure does occur it is because they are more interested in the sciences than in their students and in the school community. They fail because they do not have a realization of teacher responsibility to the school—and not because they are unable to teach well the sciences.

What do teachers consider to be the causes of teaching failures? In order to obtain the answer to this question a group of some fifty teachers (scattered over several states) was selected and letters written asking what they considered to be the causes of teacher failure in science teaching. In all cases the teachers were known to possess a proper amount of academic training in the sciences. The teachers were assured that the opinions expressed by them would be treated as confidential—and that their names would not be used in any written report that might be published giving the results as developed from the survey

—or from a summary of the opinions. The replies received indicated a real and sincere interest in the problem. Here are a few of the suggested causes of teaching science failure:

(1) Several teachers expressed the thought that inefficiency caused by not using the proper equipment or not using it at the opportune time leads to teaching failure. This situation leads to a poor opinion of the teacher in question by the administration as well as by pupils and fellow teachers. Since the study of science is based upon the scientific or experimental method, it is logical to conclude that skill in laboratory practice is essential and lack of this skill and its various implications lead to certain failure. Along this same line teachers maintain that the individual who cannot efficiently organize, maintain and care for laboratories will find the following adverse conditions and outcomes: (a) Valuable time wasted by both teachers and students in looking for or distributing materials and equipment; and (b) materials deteriorating from improper storage or lack of use.

(2) Many of the replies emphasized the lack of professional training in the specific type of science work which the teacher on the job must perform as being a common cause of failure among young instructors. These teaching failures lack the training or the ability to set up apparatus—and they do not know how to order equipment. Apparently few teachers have ever received any training that would help them make up an intelligent order for equipment and chemicals—an order needed to put the high school laboratory in proper shape to take care of a given number of classes for a semester. This lack of training forces the teacher to guess as to the quantity of this or that article needed. This system of guessing usually ends up with a shortage on some articles, and an overabundance on others. This causes a waste of money and time in buying and in storage space. There is much evidence that very few teachers ever received training during their college courses in the care and maintenance of science laboratory equipment. As a result, when they are in complete charge, for the first time, of their own laboratories, they do not know how to take care of equipment either for the sake of efficiency, for getting work done, or with the view of making it last longer.

(3) Teachers are very sure that during their training period they should have their work made more practical. There is need for placing a greater emphasis on exactly how the student—when he becomes a teacher—will conduct a typical science class

in the high school. The thought was expressed many times in the replies received from teachers that most of us know what to teach but not all of us know how to teach it.

(4) A rather large group of teachers feel that the cause of much teacher failure in the sciences is to be found in the demand —during the past fifteen years—for the general information science courses. Several teachers mention that many sincere school administrators have felt that the introduction of these courses to be an evidence of progress. The elimination of much of the individual work resulted, and much emphasis was given to the demonstration by the teacher. Many people did not realize that the introduction of indefinite and vague work in the field of the exact sciences would develop a lack of appreciation, and even a contempt for the true and exact sciences. The scientific method was in disrepute. The harm has been done and many science teachers are considered failures through no fault of their own.

(5) One teacher makes the rather interesting statement: "I feel that I failed as a science teacher during the first three years out of college. My principal and pupils never knew the fact. I know my reason for failure was due to the too intense specialization in one field of science while in college—and a lack of breadth and understanding of allied science subjects. We would all be better teachers at the secondary school level if we had good basic understanding of the many sciences rather than just a great deal regarding one narrow science field."

(6) A large portion of this group of teachers feel that failures as science teachers seems to have nothing to do with their teaching. They claim their basic training in the sciences to be excellent. They maintain that their classroom work and laboratory methods always seems to produce well taught pupils. Their trouble goes back to the office red tape:—some of these teachers claim that their administrators have always appeared to go out of their way in making unnecessary record keeping requirements. That they have to spend at least two hours each day in making out records for the office. They all realize that a high school cannot function without a somewhat detailed system of records and reports—but they would like a little more time in which to teach their science classes. If given a little more time in which to teach, they are sure that they would be successful science teachers.

These teachers have frankly discussed teacher failure in sci-

ence teaching. They have also suggested the remedies. Most of them would like to see teacher training institutions inaugurate or adopt professional courses in chemistry, physics, and biology which would incorporate the setting up of high school science apparatus, give information regarding the equipping and operating an ordinary high school laboratory. They feel that when this is done our laboratory courses will function as we know they should. It is their sincere belief if this could be done, the majority of beginning science teaching failures would be prevented. There is no question in their minds that the portion of the work which the student actually does himself in the laboratory will be the portion of his work which will do him the most good. Several mentioned that the training that men receive in the Army and Navy is practical—"do it yourself"—type of education. It is effective education.

In nearly all of these answers one senses the feeling that the majority of teachers have a good basic understanding of the sciences—but that they have not been taught to teach this knowledge—or if they have been trained in how to teach the sciences the training has not been effective.

There is no intention on the part of the writer to assume that the results or conclusions that might be reached are possessed of real validity—but he does claim that the opinions of experienced science teachers should be given careful and thoughtful consideration. These opinions point to the need for research—and the obtaining of the correct solution.

COLOR AFFECTED BY AMOUNT OF ACIDITY

Red roses and blue cornflowers have the same pigment or same dye, but the cell sap of the rose is more acid and that of the cornflower more alkaline. This causes the difference in color. Dr. Walter J. Hamer of the pH Standards Section of the National Bureau of Standards told members of the Colorists of Washington and Baltimore.

The amount of hydrogen ion in a solution is given by a pH number—a measure of the degree of acidity or alkalinity. It can be determined by using chemical substances which change color when the amount or the concentration of hydrogen ion reaches a critical point.

The degree of acidity or alkalinity is important to the textile industry in preventing pipes from rusting and in canning food.

Shoes won't wear so well if there too much acid in the leather. Papers, rare books and art objects last longer when the humidity is kept slightly alkaline. Acid bleaching is destructive to paper.

A PROPOSED SCIENCE SEQUENCE

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The construction of any proposed curriculum for any level must involve not only the preceding but also the succeeding levels. Because I am more familiar with the upper levels than with the elementary levels, my remarks will be confined to the Junior and Senior High sequences.

Any serious consideration of the science curriculum must involve certain fundamental aspects of the problem. Some of these have specific bearing on our problem and will be treated as follows:

A. I believe that in the ultimate analysis, the teacher *is* the curriculum. The mere laying out of a course of study does not insure its presentation. It makes little difference which textbook the committee may select, for the teacher edits the material anyway. One teacher may blithely skim over the difficult parts, rationalizing his acts by stating that it was beyond the comprehension level of the class. Another may ignore the excellent thought provoking material in the textbook and consider only the bare facts presented. Still another may talk about understanding and application but may test solely for facts and the pupils realizing that the facts count most, prepare accordingly. It is evident then that a course of study is of value, in proportion to the ability of the teacher, to interpret and use the material effectively in the classroom. But what determines a teacher's ability to use a curriculum? Of the many possible factors I believe that the following are primarily important:

1. The preparation of the teacher for the specific course he is teaching and his interest in the field in which he works. This problem is too complex to be treated here but in passing I wish to raise this question. How many teachers have taken an integrated general science course? Perhaps we should have better science teaching if we offered a college level course in general science. There is more general science taught than any other science and yet our teacher training institutions offer less specific training in this field than in any other. I propose then that a broad overview of the whole field of science be presented at the college level. The focus of this course should be the understanding and application of the principles studied.

2. The second important factor in the ability of the teacher to

to use a curriculum is his philosophy. What is meant by the word philosophy? To me a philosophy is the "cortex" of the teaching process. All of the stimulae of the day are received and all of the activities are initiated in terms of a philosophy. If the teacher has no philosophy, his activities become a series of random choices of action. Over a period of time some proficiency may be obtained, but any deviation from the usual situation results in chaos again.

What is a desirable philosophy? The following ideas from the foremost educational thinkers of the day seem to stand out. A science teacher is an educator in the field of science. Education is or may be defined in terms of growth and development of the pupil. Growth and development however involve much more than information and memorization. To achieve growth we must be concerned with experiences rather than recitations and with understanding rather than repetition. Mastery cannot be measured in terms of parrotlike reproduction of facts. It must be measured in terms of ability to use facts in solving the problems of life. Specifically, science must be experienced, understood and be usable in order to be of value. What is meant by the word science? Charles Kettering, the eminent research engineer, defines a science laboratory not in terms of a room filled with instruments, but rather as a "state of mind." Science is method, not apparatus, facts, or chemicals. The curriculum must offer opportunity for the pupil to grow and develop in the knowledge and use of the Scientific Method. How can teachers be stimulated to develop a desirable philosophy? This problem also is too complex to be treated here. It is a challenge to our training schools!

B. It might be assumed from the conception of science just stated that a radical change in curriculum and procedure would be necessary. I do not believe this to be true. The most pressing change needed is a ***redirection*** of emphasis in terms of the outcomes listed in the preceding paragraph. Granting the acceptance of this viewpoint, how shall we teach method? The nature and definition of the scientific method is so well known that there is no need for elaboration at this point. The meaning of emphasis on outcomes may be illustrated by considering for a moment the training of an athlete or a musician. No one ever learned to swim by sitting on the bank watching others and no one ever learned to play the piano by reading how to do it. It is necessary to participate and experience for oneself, in order

that the detailed directions become meaningful. If a person must swim in order to learn to swim, how then can he learn to think without thinking? The water in the case of the swimmer is the means by which he achieves his goal and is not the ultimate goal. The real aim is to learn to swim. In science we do not learn facts, principles and theories for their own sake. We need to know the laws and facts and to solve problems involving these laws, so that an ability may be developed which will enable the student to cope with increasingly difficult situations. We want students to learn to solve life problems. There seems to be considerable evidence to show that transfer of training is only effective if the new situation has elements in it that are common to a known and already mastered situation. It would seem that our science teaching will be effective only to the extent that the school work closely parallels true life situations. The student must be instructed or shown how to use the scientific method by setting up problems closely related to their environment, and then by having them solve these problems, using the steps in the scientific method. Obviously no drastic curricular changes are necessary to achieve this aim.

C. A study of the enrollment data clearly shows that far too few students are taking science especially the advanced courses. Education in a democracy is not a privilege, it is, a responsibility. Only a dictatorship can *tolerate illiteracy*. By illiteracy here I refer to incompetence in the understanding and control of one's environment. A democracy thrives on the utmost development of all of the diverse talents of every individual. Our experience in this war has shown that it is every person's duty to become as highly trained as his ability will allow. That this is necessary and has *not* been achieved is evident by the tremendous educational program of the armed forces. The student who dodges the difficult courses is just as much a slacker as the worker who loafs on a war job. To be sure these courses are "no snap," but there is very little growth, where there is no effort expended. The pressure for technical training that has been exerted by the armed forces has simplified the problem of selling science to the students and to the public. We must not lose this advantage by the use of obsolete curricula and inefficient methods.

D. What specific improvements in methods should be made?

1. Teachers should realize that there exists a wide range of reading ability in any class below the graduate level. Criticism

of the elementary school does not in any way solve the problem. Something constructive must be done. Textbooks can be more carefully written. Larger and more extensive illustrations should be included. Thought provoking problems and illustrations should be more plentiful. Extensive remedial reading programs should be initiated and continued until their need no longer exists.

2. It has been known for some time that there are several types of reading. The skills needed for the reading of Bamby or Black Arrow are not the same as those needed to obtain understanding from a paragraph taken from a science textbook. Special reading helps are now available and should be utilized. This seems to be a fine opportunity for relating the work of the English and Science departments.

3. There seems to be a wide range of ability on the part of pupils to interpret and derive information from charts, diagrams and drawings. This is probably due to lack of familiarity with common drafting procedures along with the usual variation in past experience. Students need help and instruction in order for them to profit by the illustrations which will appear in ever increasing amounts in the new curricular material.

4. The visual aids developed by, and for, the armed forces should be fully explored. The techniques involved in the proper use of visual aids should be carefully studied. Visual aids should be looked upon as a novel, interesting, educational experience and not as a movie shown for entertainment purposes.

5. The learning difficulties involved in the understanding of any principle or application should be given careful and thorough consideration. The experienced teacher often fuses several steps in the development of a concept. The able pupil is able to bridge the gaps in the development but this is not true for many less able in the same class. Those who do not see the relationships usually resort to memory, which is a very poor substitute for understanding. The successful solution of this problem will usually solve the motivation and discipline problems also. This phase of the teaching situation is, I believe, one of the most critical in the whole process.

E. What shall be included in the sequence?

The whole science program should be reexamined in order to secure proper grade placement of the various topics. There is no lack of curricular material. Duplication of topics especially in the upper levels should be avoided. The problem today is to

find the time, in which to obtain, the desired outcomes. Curriculum planning should include a consideration of *Time*, *Life*, *Fortune*, *Architectural Forum* and trade magazines in order that a glimpse may be had of the kind of a world that the student will live in. There should be no "ox-cart focus" in an "air age."

Recent developments in diverse fields have created a need for an expansion of the time spent in studying physics and chemistry. Part of this time is needed for a more intensive study of the courses and part for the study of new units.

I propose then that general science be given in the 7th and 8th grades, biology in the 9th, a physical science course in the 10th, chemistry in the 11th and physics in the 12th grade.

Since pronounced changes are suggested for only the 7th, 8th, 10th, 11th, and 12th grades a suggested and tentative list of units is given below.

Grade 7

The Method of The Scientist
Linear Measurement
Air and Air Pressure
Rocks, Soils, Building Materials
Water, Purification, Plumbing
Man and the Necessities of Life

Grade 8

Fire, Nature, Uses, Fuels, Burners
Heat, Movement, Heating, Ventilation
Climate and Weather Prediction
Magnetism, Electricity, Circuits
Machines
Sound and its Properties
Light, Nature and Applications
Solar System, Earth, Finding Locations
Soils and Plants

Grade 10

Elements, Compounds, Mixtures
Oxygen, Hydrogen
Water, Solutions
Properties of Matter
Mechanics of Liquids
Mechanics of Gases
Mechanics of Molecules

Grade 11

The Nature of Matter
The Atomic Theory
Valence and Equations, Weight Problems
Acids, Bases, Salts, Neutralization, Hydrolysis
Carbon, Carbon Compounds, Rubber, Plastics
Ceramics, Alloys, Metallurgy
Analytical Techniques

Grade 12

Machines, Work
Heat and Power, Engines
Sound—Music
Electricity and Electronics
Light and Optical Devices
Photography

The institution of the Pre-Induction program was indeed an indication that the schools had not planned adequately for the present to say nothing of the future. In order to regain our leadership we must be able to offer a dynamic program, one that offers opportunity for growth and development into a participating citizenship. The sequence just mentioned is offered as a first step toward such a program.

NEW OFFICERS FOR SPENCER LENS

At a meeting of the Directors of the Spencer Lens Company, Buffalo, N. Y., Scientific Instrument Division of the American Optical Company, on Friday afternoon, March 24, the following officers were elected:

Heywood Fox—President
Harold D. Rhynedance—Vice-President in charge of Sales
Walter G. Buckley—Vice-President in charge of Manufacturing and Chairman of the Board
Bryant Glenny—Treasurer and Ass't. Secretary
E. E. Williams—Ass't. Treasurer
Charles W. Barton—Secretary

The new President was born at Pelham Manor, N. Y., was graduated from Harvard in 1933, then spent three years with the Chase National Bank before going to the American Optical Company as Assistant to the President.

He joined Spencer as Assistant to the President, January 1, 1941, to handle negotiations with the Navy Department and War Department. Many of the optical instruments heeded by the Armed Forces were new to Spencer. They were either new instruments which had to be designed or existing instruments which involved redesigning or adaptation for new applications.

Mr. Fox coordinated activities within the Company, and between the Company and the armed services. Many contracts have been successfully completed and a heavy schedule of instruments is now in production.

During the National Defense Program and the present war period, the Spencer Lens Company has continued producing in unprecedented numbers the microscopes, projectors and other scientific instruments for which they were famous in peace time.

War products have included tank sights, azimuth instruments for directing artillery fire, battleship turret gunsights, aircraft and anti-aircraft gunsights, turret periscopes, prism binoculars and telescopic alidades for navigation.

LITTLE CLIMATES

This is the title of an excellent 32-page booklet for the youngsters in a class in nature study or elementary science. It is Number 3 of Volume 37 of *Cornell Rural School Leaflet*, and contains more good science than will be found in many sections of some elementary science texts of three times its size. It is well illustrated and especially adapted for the school in New York State but the youngsters in any other locality will enjoy every bit of it.

SOME FACTORS INFLUENCING FINAL MARKS IN AN INTRODUCTORY COURSE IN COLLEGE BIOLOGY

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INTRODUCTION

It is generally recognized that marks in college courses do not necessarily measure the student's actual ability nor the extent of his endeavor. Nevertheless, grades are significant in that they tend to classify the student with respect to his fellows. If fair and comprehensive examinations have been given with sufficient frequency in well spaced intervals, the final results should be a fair measure of the relative achievement of the student in the course.

The course in biology to be considered in this paper is a 4-credit course required of all students who intend to graduate from the College of Agriculture at the University of Nebraska. The course provides four 1-hour lecture periods and one 3-hour laboratory period per week during one semester. He must receive a grade of 60 or more in order to receive credit. Sometime during the latter part of the semester students are requested to answer the following questions:

1. Have you had in high school a course in (a) biology (b) botany (c) zoology (d) nature study?
2. Do you like this course (biology) (a) better than (b) the same as (c) less than the average college course?
3. Do you consider this course (a) more difficult (b) equally difficult (c) less difficult than the average course?

It was clearly explained that there should be no consideration of the probable feelings of the instructor and that answers given were to be kept absolutely confidential and were to have no bearing whatever upon their grades.

RESULTS

Data are available for five semesters from the records of 622 students, 324 boys and 298 girls. As a matter of interest, the performances of boys and girls have been compared. Final examination averages for each semester (table 1) varied from marks of 68 to 76, with an average of 72. Apparently the difficulty of the final examinations varies considerably from year to year but as was to be expected, final grades showed less variation

from semester to semester due to the regression of averages based upon weekly class examinations, bi-monthly laboratory examinations, six-weeks hour examinations, and weekly laboratory

TABLE 1. FINAL EXAMINATION MARKS COMPARED WITH FINAL MARKS FOR 622 FRESHMEN IN BIOLOGY FOR FIVE SEMESTERS, 1939–1942

	1939–1940 2nd semester		1940–1941 1st semester		1940–1941 2nd semester		1941–1942 1st semester		1941–1942 2nd semester		Summary of Five Semesters, 1939–1942			
	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.	Per cent of total	Per cent of boys and girls
Final exams:														
Total	133	68.1	146	72.0	88	76.5	170	72.3	85	76.2	622	72.4	100.0	—
Boys	52	68.6	90	71.4	40	80.0	98	68.3	44	78.2	324	72.0	52.4	100
Girls	81	67.7	56	72.9	48	73.5	72	77.7	41	74.1	298	72.9	47.6	100
Final grades:														
Total	133	73.1	147	73.9	88	75.3	171	73.9	89	72.9	628	73.8	100.0	—
Boys	52	72.7	91	72.8	40	78.1	99	70.3	47	74.2	329	72.8	52.4	100
Girls	81	73.3	56	75.5	48	73.0	72	79.0	42	71.5	299	74.8	47.6	100

TABLE 2. COMPARISON OF FINAL MARKS OF FRESHMEN IN BIOLOGY WHO HAD WITH THOSE WHO HAD NOT HAD PREVIOUS BIOLOGY, 1939–1942

	1939–1940 2nd semester		1940–1941 1st semester		1940–1941 2nd semester		1941–1942 1st semester		1941–1942 2nd semester		Summary of Five Semesters, 1939–1942			
	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.	Per cent of total	Per cent of boys and girls
Previous biology:														
Total	71	73.1	87	75.0	49	76.7	93	73.9	60	72.5	360	74.1	57.9	—
Boys	25	71.8	57	73.3	25	78.4	51	69.4	30	75.8	188	73.0	—	57.8
Girls	46	73.9	30	78.2	24	74.8	42	79.5	30	69.1	172	75.3	—	57.9
No previous biology:														
Total	62	73.0	60	72.3	37	73.8	78	73.9	25	77.5	262	73.6	42.1	—
Boys	27	71.8	34	72.2	14	78.1	48	71.2	14	76.9	137	73.2	—	42.2
Girls	35	72.7	26	72.5	23	71.1	30	78.3	11	78.3	125	74.2	—	42.1

papers. The range of averages of semester marks was from 73 to 75. (These figures, and all others, were obtained by averaging the marks of all students, including the marks of those who failed).

Girls received final marks which averaged just two points (about 3%) higher for the group of 298 than those for the group of 324 boys. This is not consistent for each semester but it may indicate a tendency. Pertinent to this point is the fact that Ag College freshmen boys rank about $\frac{1}{4}$ of a standard deviation lower than the Home Economics girls in their preregistration guidance examinations, a condition which may be partially due to the fact that farm boys too often have not had the high school courses which would best prepare them for college.

Continually the plaint is heard "I've never had any biology, so you can't expect me to do as well as others." In order to test the validity of this excuse, marks of those having had previous biology were compared with those who had not (table 2). The average grade for the 360 students having had previous biology was 74.1 and that for the 262 who did not have that privilege was 73.6, a difference of one-half of a per cent. Girls alone seemed to have benefited by a previous exposure to the instruction in biology.

Contrary to the above results, those students who like the course better than the average of their other courses have a distinct advantage but if they dislike the course, i.e., like it less than the average, their marks suffer accordingly (table 3). A gap of 10 percentage points separates the "likes" from the "dislikes." Other courses taken by these students are mostly in English, agriculture, and home economics. Here one may venture the thought that courses should be made as attractive as possible for freshmen students. According to these data, the 76 girls who liked the course less were not quite so much affected by their dislike as were the 86 boys.

But what about the difficulty of the course. Do students who find the course difficult tend also to give poor results as measured by grades (table 4)? For the 622 students here considered, the greater the difficulty of the course the poorer the grades, the less difficult the course the better the grades. Girls received consistently higher grades in each of the three classifications shown in the table. There is always a suspicion that the poorly equipped student will naturally find the course more difficult and as a consequence dislike it. Will a course which is difficult be less attractive to many students? Observation of the tables shows very great correlation between the classifications "more difficult" and "less appealing." Many of those who find the course difficult also find it less appealing and vice versa.

TABLE 3. COURSE APPEAL AS IT AFFECTS FINAL MARKS OF FRESHMEN IN BIOLOGY, 1939–1942

	1939–1940 2nd semester		1940–1941 1st semester		1940–1941 2nd semester		1941–1942 1st semester		1941–1942 2nd semester		Summary of five Semesters, 1939–1942			
	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.	Per cent of total	Per cent of boys and girls
Like course better:														
Total	36	77.5	23	79.8	18	80.7	23	80.5	19	79.1	119	79.3	19.1	—
Boys	13	77.3	10	80.5	9	80.4	12	79.0	11	79.5	55	79.2	—	16.9
Girls	23	77.7	13	79.5	9	81.0	11	82.2	8	78.6	64	79.4	—	21.5
Like course same:														
Total	66	71.5	90	74.0	45	77.0	97	77.6	43	72.7	341	74.8	54.8	—
Boys	30	71.0	61	73.8	20	81.0	52	75.2	21	75.6	184	74.7	—	56.6
Girls	36	71.9	29	74.4	25	73.9	45	80.4	22	70.0	157	74.9	—	52.9
Like course less:														
Total	31	71.3	34	69.6	23	68.1	51	68.0	23	71.8	162	69.5	26.1	—
Boys	9	71.6	20	66.3	10	71.1	35	65.6	12	74.2	86	68.2	—	26.4
Girls	22	71.2	14	74.2	13	65.8	16	73.1	11	69.7	76	71.0	—	25.6

TABLE 4. COURSE DIFFICULTY AS IT AFFECTS FINAL MARKS OF FRESHMEN IN BIOLOGY, 1939–1942

	1939–1941 2nd semester		1940–1941 1st semester		1940–1941 2nd semester		1941–1942 1st semester		1941–1942 2nd semester		Summary of five Semesters, 1939–42			
	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.	Per cent of total	Per cent of boys and girls
Course more difficult:														
Total	77	71.1	83	72.0	49	70.6	105	70.1	51	69.3	365	70.7	58.8	—
Boys	31	70.3	51	71.7	18	73.6	64	65.9	23	71.5	187	69.6	—	57.7
Girls	46	71.8	32	72.3	31	68.9	41	76.7	28	67.5	178	71.8	—	59.9
Course same difficulty:														
Total	51	75.0	60	77.8	35	81.6	59	79.0	30	80.4	235	78.4	37.8	—
Boys	19	75.3	38	76.5	20	82.5	30	76.8	19	81.1	126	77.9	—	38.9
Girls	32	74.9	22	80.1	15	80.9	29	81.2	11	79.3	109	79.0	—	36.7
Course less difficult:														
Total	5	83.8	3	72.7	2	85.5	7	88.1	4	85.0	21	84.0	3.4	—
Boys	2	84.5	1	65.0	1	89.0	5	86.4	2	83.0	11	83.9	—	3.4
Girls	3	83.3	2	76.5	1	82.0	2	92.5	2	87.0	10	84.4	—	3.4

Do those students ranking low, i.e., in the lower one-third, in their guidance examinations also find the course more difficult as well as less appealing? Here it may be of interest to explain briefly some things about the guidance examinations. These examinations are given by competent instructors under the direction of the University Bureau of Instructional Research. One test is the American Council on Education Psychological examination which provides part scores on the linguistic or ability with words (L) and another measures the quantitative or the ability with numbers (Q). Dependent upon scores received in these and other tests, students were classified into $\frac{1}{4}$ sigma-groups from 1, the highest, to 9, the lowest. The $(L+Q)$ scores were thought to constitute a fair measure of the student's possibilities of progress in a course in biology and have been used as such a measuring appliance ($r=60$). Of the 145 students in the lower one-third, i.e., with scores of 7, 8, or 9, 73 per cent found the course more difficult and only 1 per cent less difficult than the average course. Only 59 per cent of *all* students found the course more difficult and 3 per cent found it less difficult. Also only 8 per cent of the lower one-third found the course more appealing while 31 per cent found it less appealing. The averages of the entire class for these two factors were 19 and 26 per cent, respectively. It may be of additional interest to contrast the average final grades of these groups. The class average was 74. The average of those finding the course more difficult was 71; less difficult, 84; more appealing, 79; and less appealing, 70.

Summary

1. Final marks in a 4-credit freshman course in biology averaged 2 points higher for girls than boys.

2. Students who have had no previous biology should have little or no handicap in the course since there were no significant differences between their marks and those of students having had previous biology.

3. Those students who liked the course better than the average course received considerably higher than average grades and those students who liked the course less than the average received grades much lower than the average.

4. In general, the greater the difficulty of the course the poorer the grade and the less the difficulty, the better the grade.

5. Generally speaking, students ranking in the lower one-third in their guidance examinations find the course more difficult as well as less appealing.

AGAIN THAT QUADRATIC EQUATION

ARTHUR PORGES
Camp Roberts, California

If any mathematical subject truly can be said to be exhausted, the quadratic equation in one variable surely comes closest to filling the bill. Therefore, some explanation is needed to justify a whole article devoted to nothing but solutions of that overworked equation.

At a meeting of amateur "philomaths," one wag suggested that we all get busy and see how many different methods of solving a quadratic we could "invent" in half an hour. The results were interesting if not too informative, and it occurred to the writer that *some* textbook *sometime* ought to derive the quadratic formula without recourse to completion of the square.

It seems possible, at least, that a superior student, given a lead on one of the derivations to follow, might increase his mathematical maturity by completing the solution and gain considerable enjoyment as well.

The derivations themselves, which by no means exhaust the total, are arranged in order of increasing difficulty, but remain well within the domain of the most elementary mathematics.

METHOD A

In the equation

$$AX^2+BX+C=0$$

let $X=Y+b$. Substituting and reducing:

$$AY^2+(2Ab+B)Y+Ab^2+Bb+C=0.$$

Let $2Ab+B=0$. Then the term in Y vanishes and

$$AY^2+Ab^2+Bb+C=0$$

becomes

$$4A^2Y^2-B^2+4AC=0.$$

Solving for Y:

$$Y=\pm\frac{\sqrt{B^2-4AC}}{2A},$$

and from $X=Y+b$, we have

$$X=\frac{-B\pm\sqrt{B^2-4AC}}{2A}.$$

METHOD B

In the equation

$$AX^2+BX+C=0$$

let $X=t+iv$, where $i=\sqrt{-1}$, and $tv\neq 0$. Substituting and reducing:

$$At^2+Bt+C-Av^2+2Atvi+Bvi=0.$$

Setting the real and imaginary parts of the equation equal to zero, we have

(1) $$At^2-Av^2+Bt+C=0.$$

(2) $$2Atv+Bv=0.$$

Since $v\neq 0$, $t=-B/2A$, and substituting in (1), we have

(3) $$4A^2v^2+B^2-4AC=0.$$

Solving (3) for v, we get

$$v=\pm\frac{\sqrt{4AC-B^2}}{2A}.$$

But $X=t+iv$, whence we have

$$X=-\frac{B}{2A}\pm i\frac{\sqrt{4AC-B^2}}{2A},$$

or, finally

$$X=\frac{-B\pm\sqrt{B^2-4AC}}{2A}.$$

METHOD C

Let the roots of $AX^2+BX+C=0$ be X_1 and X_2. Then

(4) $$X_1+X_2=-\frac{B}{A}$$

(5) $$X_1X_2=\frac{C}{A}.$$

Squaring (4) and subtracting four times (5), we have

$$X_1^2-2X_1X_2+X_2^2=\frac{B^2}{A^2}-\frac{4C}{A}$$

whence

$$X_1 - X_2 = \pm \frac{\sqrt{B^2 - 4AC}}{A}. \tag{6}$$

Solving (4) and (6) simultaneously, we get

$$X_1 = -\frac{B + \sqrt{B^2 - 4AC}}{2A}$$

$$X_2 = -\frac{B - \sqrt{B^2 - 4AC}}{2A}.$$

METHOD D

In the equation

$$AX^2 + BX + C = 0, \quad \text{let} \quad X = \sqrt{\frac{C}{A}} \tan \theta.$$

Substituting, we get

$$C \tan^2 \theta + B\sqrt{\frac{C}{A}} \tan \theta + C.$$

Since $1 + \tan^2 \theta = \sec^2 \theta$, we now have

$$C \sec^2 \theta + B\sqrt{\frac{C}{A}} \tan \theta = 0,$$

or

$$C + B\sqrt{\frac{C}{A}} \sin \theta \cos \theta = 0,$$

whence

$$\sin 2\theta = -\frac{2C}{B\sqrt{\frac{C}{A}}}.$$

By the use of simple trigonometric identities we find that

$$\tan \theta = \frac{1}{2C\sqrt{A}} \left[-B\sqrt{C} \pm \sqrt{B^2C - 4AC^2} \right].$$

Since

$$X = \sqrt{\frac{C}{A}} \tan \theta,$$

we get

$$X=\frac{-B\pm\sqrt{B^2-4AC}}{2A}.$$

METHOD E

The following rather "precious" derivation was voted illegal, but does show a certain perverted ingenuity!

Consider the identity

$$2AX+B\equiv 2A\left(X+\frac{B}{2A}\right).$$

Multiplying both sides by dx and integrating, we get

$$F(X)=AX^2+BX+C\equiv A\left(X+\frac{B}{2A}\right)^2+K=0.$$

Now K is obviously equal to

$$F\left(-\frac{B}{2A}\right), \quad \text{or} \quad \frac{4AC-B^2}{4A},$$

whence

$$\left(X+\frac{B}{2A}\right)^2=\frac{B^2-4AC}{4A^2},$$

and

$$X=\frac{-B\pm\sqrt{B^2-4AC}}{2A}.$$

VIRUSES ARE NOT LIVING ORGANISMS LIKE OTHER GERMS

Viruses, the causes of many diseases including the common cold and infantile paralysis, are not living organisms like other disease germs but complicated protein chemicals, inanimate in nature, in the opinion of Prof. Roger J. Williams, director of the Biochemical Institute of the University of Texas.

The reason for his opinion is based on findings at the Clayton Foundation showing that viruses apparently do not contain any B vitamins. Appreciable amounts of the various B vitamins have, however, been found in all forms of living matter which have been investigated.

NOTES FROM A MATHEMATICS CLASSROOM

JOSEPH A. NYBERG
Hyde Park High School, Chicago, Illinois

79. Belittling Algebra. During the first months of algebra many of the new concepts can be illustrated only by using very simple problems, and in many cases the pupil feels that the problems can be solved more easily by arithmetic than by algebra. To foster the proper attitude teachers use various illustrations, such as comparing the learning of algebra to learning to ride a bicycle. "When learning to ride you doubtless feel that walking will get you to your destination sooner and cause fewer bruises; nevertheless, we know that it pays to learn to ride. Likewise, at first it seems that algebra solves problems that can be solved just as easily by arithmetic. But, have patience and you will find that algebra does things that arithmetic cannot do. And we must start with the simple problems before we can tackle the difficult ones."

The kind of work referred to is illustrated by problems like:

Use the formula $A=lw$ to find the area of a rectangle that is 8 ft. long and 6 ft. wide. (The pupil thinks, "I knew how to find the area of a rectangle before I began algebra.")

John is 12 yr. old. He is one fourth as old as his father. How old is his father? (The pupil thinks, "I can find the father's age without writing an equation.")

In 5 hr. Jim drove 150 mi. What was his average rate? (The pupil thinks, "I don't need an equation or need to substitute in any formula to find this answer.")

Use the formula $p=a+b+c$ to find the perimeter of a triangle whose sides are 5 in., 6 in., and 7 in.

Write and solve the equation for this problem: What number added to 6 makes 16?

It is work of this type that "belittles" algebra, that makes the pupil say, "Algebra is arithmetic done in a hard way." The teacher can try to avoid this complaint in such ways as: (1) Use the bicycle versus walking explanation, (2) Omit the problems that can be solved by arithmetic, or (3) Allow the pupil to solve the problem by arithmetic and then show that algebra contributes something that arithmetic overlooks. The last method is obviously the best one *when it can be used*. I discussed

its possibilities in a previous NOTE, June 1942, for problems that deal with formulas.

To avoid trivial problems when introducing equations, we can use percentage problems. If n is r per cent of b, we have three problems according to whether n or r or b is unknown. In arithmetic we have three distinct rules, one for each problem. But algebra can contribute that "extra something" to these problems; it reduces the three rules to one rule: Substitute the known numbers in the equation and solve for the unknown.

Again, arithmetic can solve the problem:

What is the cost of some goods if, after a profit of 10% of the cost, the goods are sold for \$1.65?

But algebra can contribute an "extra something" by indicating the general relation for many problems of this type. An early use of such problems helps to eliminate trivial work.

It is not only during the first month that algebra gets belittled. Unless we watch our methods, the belittling will reappear. For example, after studying algebraic fractions we study equations containing such fractions. And even if we feel that ninth grade work should not involve trinomial denominators, we at least consider such equations as

$$\frac{x-4}{x-2}+\frac{1}{x-3}=1 \qquad \frac{6}{x+2}-\frac{4}{x-2}=\frac{x-28}{x^2+2x}$$

and then, to justify such work, we study problems that lead to fractional equations. But, unfortunately, the problems may lead equations like

$$\frac{1}{3}+\frac{1}{6}=\frac{1}{x} \qquad \frac{x}{6}=\frac{x-3}{4}.$$

And the pupil is right when he says, "I could have solved such problems without all this study of complicated equations."

As another example, consider the multiplication of binomials. We handle such expressions as $4(x-5y)(2x+3y)$ and then solve a problem like:

One number is three halves of another. Their product is 24. Find the numbers.

It is impossible to find sensible problems that will lead to equations involving all types of operations that are studied. Further, this should not be a reason for omitting work on the formal operations. In fact, I favor more of it, and favor tri-

nomial denominators, and complicated fractions, and hope the war will bring back the tough work which filled the books of twenty years ago. But I want to be honest about it, and wish to avoid anything that may belittle algebra. The problems that lead to rather simple equations should be studied *before* the complicated formal operations are studied. And the complicated formal operations will be justified on the ground that it is used in later courses in mathematics, and this is a good time for the pupil to study this material. On the bulletin board in the classroom there should be placed a few samples of the problems in which these skills are needed.

Besides posting on the bulletin board some problems that the pupils do not care to tackle, there are some other devices that can be used, such as:

(1) Use the appeal: Don't you like to try a difficult problem occasionally just to see if you are bright enough to do it?

(2) Tell the truth: These are not sensible problems. The chief difficulty is in understanding the English and finding the relations between the numbers. You need not solve the equations after you have found them.

(3) Solve these problems by arithmetic. But the best check in the world is that of solving a problem in two different ways. Use the algebraic method as a check.

(4) Let the pupils invent some problems that lead to the kind of expressions that have been studied. If a pupil invents the problem there will be no danger of his thinking that the problem is trivial.

And finally, I suggest that the class in pedagogy study the question: How can we avoid belittling algebra?

80. Engineering Problems Illustrating Mathematics. Teachers need a supply of problems that can be used to show pupils what lies ahead of them. A handy reference book is the 1942 Yearbook of the National Council, entitled a *Source Book of Mathematical Applications* (Bureau of Publications, Columbia University, $2.00). It contains material that a high school pupil can handle. A collection of more advanced material is *Engineering Problems Illustrating Mathematics* published 1943 by McGraw-Hill Book Co., 172 pages, $1.75 (with answers). It was prepared by the Mathematics Division of the Society for the Promotion of Engineering Education, and includes problems for college algebra, trigonometry, analytic geometry, differential and integral calculus. Although it is intended for col-

leges, the high school teacher can find in it many problems for stimulating interest. I keep my copy handy, and when a pupil asks, "What is this used for?" I can hand him the book and say, "Have a look at this." In it I can also find problems for posting on the bulletin board to illustrate that the algebraic expressions we are studying are a preparation for those found in real life.

81. Line Representation of Trigonometric Ratios. When every minute is important, as it is in any class, each topic must be weighed carefully to see how much attention it deserves. Some of the new texts in trigonometry have dropped any mention of the line representations, and this seems to be a step in the right direction. The lines may be interesting to a historian but they have few, if any, applications and whatever they teach can be learned in other ways. They are usually introduced as a preliminary to a study of the graphs and the variation of the functions as the angle increases from 0 to 360°.

The easiest way to draw the graphs is to have the pupil find the values of a function from a table and by using the reduction formulas. Some of the boys who have been in mechanical drawing classes like to use a geometric method. The variation of the functions can be studied by drawing a circle of unit radius and by having the hypotenuse of the right triangle equal to 1.

In the McGraw-Hill text, mentioned in a previous paragraph, a note on page 34 states "the student must have at his command an understanding of line values" but this is a reference to the need for understanding the use of lines as vectors, a topic that is bound to get more attention in the future.

82. The Definition of Proportional Segments. If AB and BC are the segments of AC, and DE and EF are the segments of DF, and if $AB/BC=DE/EF$ then AC and DF are divided in proportional segments. This is the customary definition. Some writers and teachers wish to make the definition more liberal so that it would also include the relations $AC/AB=DF/DE$ and $AC/BC=DF/EF$. In arguments about the matter I am seldom convincing when I affirm that a definition should not include an item that can be derived from the other items. But I can always win the opponents to my view by saying, "Would you also make the definition of an isosceles triangle more liberal, so that it would include both the case when two sides are equal and also the case when two angles are equal?" That seems to settle the argument.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1862, 3, 6. *Joseph Konhauser, Ford City, Pa.*

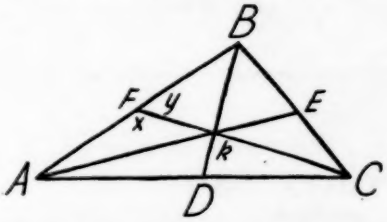
1862, 3, 4, 6. *Milton Schiffenbauer, New York City and Paul H. Renton, Westview, Pa.*

1867. *Proposed by M. Kirk, West Chester, Pa.*

Show that in a triangle the longest median is not drawn to the longest side.

First Solution by Joseph A. Wolf, Jr., Detroit, Mich.

In triangle ABC, let $AC>AB>BC$. Prove $AE>BD$.



In Δs AFC and BCF, $AF=BF$, $FC=FC$, $AC>BC$, hence $\angle x>\angle y$.

In Δs AFK and BFK, since $\angle x>\angle y$, $AK>BK$.

But $AK=\frac{2}{3}AE$, $BK=\frac{2}{3}BD$, Hence $AE>BD$, or the longest median is drawn to the shortest side.

Second solution by Helen M. Scott, Baltimore, Md. By geometry, if m_a is median to a, then

$$b^2+c^2=2m_a^2+2\left(\frac{a}{2}\right)^2.$$

From this

$$m_a=\tfrac{1}{2}\sqrt{2(b^2+c^2)-a^2},$$

which shows that m_a is least when a, is greatest.

Other solutions were offered by Hugo Brandt, Chicago; William A. Richards, Berwyn, Ill.; M. Kirk, West Chester, Pa.; Dorothy C. Hand, Clark's Summit, Pa.

1868. *Proposed by M. Kirk, West Chester, Pa.*

Show that $8\cos^3 36°-4\cos 36°=1$.

Solution by M. Kirk, West Chester, Pa.

$$\begin{aligned}8\cos^3 36-4\cos 36&=4\cos 36(2\cos^2 36-1)\\&=4\cos 36\cdot\cos 72\\&=\frac{4\cos 36\cdot\cos 72\cdot\sin 36}{\sin 36}\\&=\frac{2\sin 72\cos 72}{\sin 36}\\&=\frac{\sin 144}{\sin 36}=\frac{\sin 36}{\sin 36}=1.\end{aligned}$$

Solutions were also offered by Maude Henry, Winchester, Va.; Evangeline Fazio, Baltimore, Md.; William A. Richards, Berwyn, Ill.; Walter R. Warne, Fayette, Mo.; A. E. Gault, Peoria, Ill.; Gordon Duvall, Cincinnati, Ohio; Helen M. Scott, Baltimore, Md.; Sigismund Chamer, New York City; W. W. Gorsline, Chicago.

1869. *Proposed by Hugo Brandt, Chicago, Illinois.*

Find the integers for a, c, m, n satisfying equations

$$a^2+7c^2=m^2$$
$$a^2-7c^2=n^2$$

Solution by the Proposer

Solution. Adding both equations:

$$2a^2=m^2+n^2. \tag{1}$$

If

$$m=r+s, \qquad n=r-s \tag{2}$$

(1) becomes

$$2a^2=2r^2+2s^2, \quad \text{or} \quad a^2=r^2+s^2. \tag{3}$$

This is the well-known case satisfied by

$$a=v^2+u^2, \qquad r=2vu, \qquad s=v^2-u^2 \tag{4}$$

From $a^2+7c^2=m^2$ and (2) and (3) we get

$$7c^2=2rs,$$

and substituting from (4) the values of r and s:

$$7c^2=4vu(v-u)(v+u). \tag{5}$$

Trials show that v, u or $(v+u)$ may not equal 7. But if $v-u=7$, $v=u+7$, then

$$c^2=4u(u+7)(2u+7).$$

This yields a solution for $u=9$, $(u+7)=16=v$

$$(2u+7)=25 \quad \text{and} \quad c=2\cdot 3\cdot 4\cdot 5=120$$

Inserting $v=16$, $u=9$ into (4) yields

$$a=256+81=337; \qquad r=288; \qquad s=175.$$

Insert r and s in (2)

$$m=463, \qquad n=113$$

$$\therefore \quad a=337, \qquad m=463, \qquad n=113, \qquad c=120.$$

1870. No complete solution has yet been received.

1871. *Proposed by Alan Wayne, Flushing, N. Y.*

In the rectangle $ABCD$ if $AB/AD=AD/(AB+AD)$, show that $\angle CAD=\arctan(2\sin 18°)$.

Solution by Helen M. Scott, Baltimore, Md.

Let

$$x=AB; \qquad y=AD.$$

$$\frac{x}{y}=\frac{y}{x+y}$$

$$x^2+xy=y^2$$

$$x^2+xy+\left(\frac{y}{2}\right)^2=y^2+\frac{y^2}{4}=\frac{5y^2}{4}$$

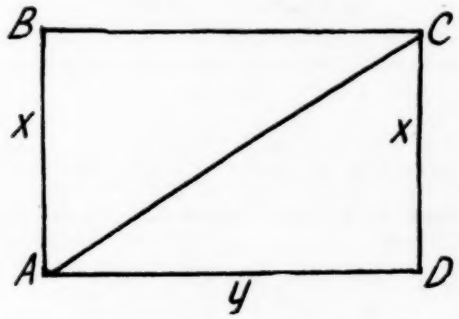
$$x+\frac{y}{2}=\pm\frac{y}{2}\sqrt{5}$$

$$x=y\left(\frac{-1\pm\sqrt{5}}{2}\right)$$

$$\tan CAD=\frac{x}{7}=\left(\frac{-1\pm\sqrt{5}}{2}\right)$$

$$\sin 18°=\left(\frac{-1\pm\sqrt{5}}{4}\right) \quad \text{(see 1868)}$$

$$\therefore \quad \angle CAD=\arctan(2\sin 18°).$$



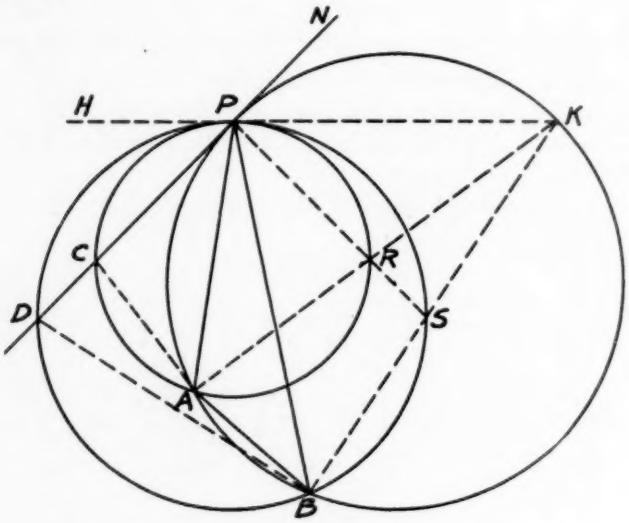
Solutions were also offered by Wm. A. Richards, Berwyn, Ill.; M. Kirk, West Chester, Pa.; W. W. Garsline, Chicago; Gordon Duval, Cincinnati, Ohio; A. E. Gault, Peoria, Ill.

1872. *Proposed by Adrian Struyk, Paterson, N. J.*

Two fixed circles, tangent to each other at P, are cut by a fixed secant which passes through P. A third circle, tangent to the secant at P, and cutting the other two circles at A and B, is variable in size. Prove that

$$\frac{AB}{PA \cdot PB}$$

is constant



Solution by the Proposer

Let PAC and PBD be the fixed circles, tangent at P, and cut at C and D by the fixed secant NP. Let the common tangent HP cut the variable circle PAB at K. Draw KA and KB, cutting the fixed circles at R and S. Draw AC and BD. From PK,

$$\angle NPK = \angle PAK = \angle PBK.$$

From PC and PD,

$$\angle HPC = \angle PAC = \angle PBD.$$

Then $\angle PAK = \angle PAC$ and $\angle PBK = \angle PBD$, since $\angle NPK = \angle HPC$. Hence $PR = PC$ and $PS = PD$; and R and S are fixed points. Thus

$$\frac{RS}{PR \cdot PS}$$

is a constant. It is evident, too, that P, R, S are collinear. Draw PRS.

On the tangent and secants from K, $KP^2 = KA \cdot KR = KB \cdot KS$. Then the common angles at K make $\Delta KAB \sim \Delta KSR$, $\Delta PAK \sim \Delta PKR$, and $\Delta PBK \sim \Delta PKS$. Hence

$$\frac{AB}{RS} = \frac{KA}{KS} = \frac{KA \cdot KR}{KS \cdot KR} = \frac{\overline{KP^2}}{KR \cdot KS},$$

or

$$\frac{AB}{KP^2}=\frac{RS}{KR\cdot KS}.$$

Also,

$$\frac{KP}{PA}=\frac{KR}{PR} \quad \text{and} \quad \frac{KP}{PB}=\frac{KS}{PS}.$$

The product of the last three results gives

$$\frac{AB}{PA\cdot PB}=\frac{RS}{PR\cdot PS},$$

a constant.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

No solutions were offered for this issue.

PROBLEMS FOR SOLUTION

1885. *Proposed by Alan Wayne, Flushing, N. Y.*

Find in radical form the roots of

$$x(x-2)(x^2-4)=2.$$

1886. *Proposed by Lloyd U. Wright, San Gabriel, California.*

Given the radius of circle A, to find the radius of circle B, whose center, P, is on the circumference of A and whose arc inside A bisects the area of A.

1887. *Proposed by Rita Dorner, Syracuse, New York.*

If $a+b+c+d=a^2+b^2+c^2+d^2=0$, then show $a^8+b^8+c^8+d^8=\frac{1}{4}(a^4+b^4+c^4+d^4)^2$

1888. *Proposed by Adrian Struyk, Paterson, N. J.*

Two intersecting chords in a circle of radius r, are perpendicular to each other. The shorter part of one is a, and the other, b. Find the distances of chords from the center.

1889. *Proposed by Harriet Letts, Interlaken, N. Y.*

Trisect a given square by straight lines parallel to one of the diagonals.

1890. *Proposed by Charles Bachulein, Spokane, Washington*

In triangle ABC, the bisectors of the interior and exterior angles at A meet BC at D and E, prove

$$DE=\frac{2abc}{c^2-b^2}.$$

A NOTE ON LONG DIVISION

HAROLD D. LARSEN
The University of New Mexico, Albuquerque, New Mexico

The process of long division is usually considered to be one of the most difficult operations in arithmetic. Much of this difficulty is due to the insistence on finding the correct quotient figure before proceeding with the division. This frequently requires two or more trials and the consequent erasures of the discarded products. Elaborate rules have been formulated to aid in determining the correct quotient figure, all of which require considerable mental computation.

As a matter of fact, the difficulty of long division has been exaggerated. The whole process is very much simplified if an incorrect product is *not* erased. If the subtraction of the trial product is actually carried out, the remainder can be used very conveniently to *adjust* the incorrect quotient figure. I have examined a large number of text-books on arithmetic, but have failed to find any discussion of such adjustments.

The following examples illustrate simple methods for adjusting trial quotients. Two cases arise, depending on whether the trial quotient is too small or too large.

Example 1.

```
        8
       71
    ------
582)47223
   4074
   ----
    648
    582
    ---
    663
    582
    ---
     81
```

Explanation. The trial quotient 7 yields a remainder 648, and hence is too small. Instead of erasing the trial product and starting over, it is more convenient to change the quotient figure to 8 by subtracting an additional 582 from 648.

Example 2.

```
        7
       86
    ------
368)28265
   2944
   ----
   -118
    368
    ---
   2505
   2208
   ----
    297
```

Explanation. The trial quotient 8 is too large, since the trial product exceeds the dividend by 118. Change the quotient figure to 7 by adding 368 to -118.

If your journal does not reach you notify Ray C. Soliday, P.O. Box 408, Oak Park, Illinois.

BOOKS AND PAMPHLETS RECEIVED

OUR AIR-AGE WORLD, A TEXTBOOK IN GLOBAL GEOGRAPHY, by Leonard O. Packard, *Head of the Department of Geography, Teachers College of the City of Boston;* Bruce Overton, *Formerly of the Male High School, Louisville, Kentucky;* and Ben D. Wood, *Columbia College, Columbia University.* Cloth. Pages x+838. 15×23.5 cm. 1944. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.80.

HEALTH FOR YOU, by Katharine Bruderlin Crisp, *East High School, Denver, Colorado.* Cloth. Pages xv+576. 13.5×20.5 cm. 1944. J. B. Lippincott Company, 333 West Lake Street, Chicago 6, Ill. Price $1.80.

VITAL MATHEMATICS, by Edwin Brown Allen, *Head of the Department of Mathematics, Rensselaer Polytechnic Institute, Troy, New York;* Dis Maly, *Instructor in Mathematics, Rensselaer Polytechnic Institute, Troy, New York;* and S. Herbert Starkey, Jr., *Head of Mathematics Department, Madison High School, Madison, New Jersey.* Cloth. Pages vii+456+xxii. 14×21.5 cm. 1944. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.80.

FOOLS AND FOOLISHNESS, by Harry C. McKown, *Editor of School Activities.* Cloth. Pages vii+263. 13×19 cm. 1943. School Activities, C. R. Van Nice, Managing Editor, 1515 Lane Street, Topeka, Kansas.

MILITARY APPLICATIONS OF MATHEMATICS, by Paul P. Hanson, M.A., *Lieutenant, United States Army (Retired); Instructor in Mathematics, The Manlius School, Manlius, New York.* Cloth. Pages xiii+447. 14×22.5 cm. 1944. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.40.

RIDDLES IN MATHEMATICS, A BOOK OF PARADOXES, by Eugene P. Northrop. Cloth. Pages viii+262. 13.5×21.5 cm. 1944. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $3.00.

INTRODUCTORY ASTRONOMY, A GUIDE FOR NIGHT WATCHERS, by J. B. Sidgwick, *Member of the Société Astronomique de France and of the British Astronomical Association.* Cloth. Pages viii+137. 14.5×23 cm. 1944. Philosophical Library, Inc., 15 East 40th Street, New York, N. Y. Price $2.50.

FIRST PRINCIPLES OF BUSINESS, by Louis A. Rice, A.M., *Principal, Packard School, New York City;* James H. Dodd, Ph.D., *Head, Department of Commerce, Mary Washington College;* and Augustin L. Cosgrove, A.M., *Chairman, Department of Business Communication, University of Oklahoma.* Cloth. Pages x+598. 13.5×21.5 cm. 1944. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $2.00.

CALCULUS REFRESHER FOR TECHNICAL MEN, by A. Albert Klaf, B.S., M.E., *Civil Engineer, Board of Water Supply, City of New York.* Cloth. Pages viii+431. 13×21 cm. 1944. Whittlesey House, McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $3.00.

BIOLOGY AND MAN, by Benjamin C. Gruenberg, *Consultant Social Security Board, Formerly Chairman, Biology Departments, Commercial and Julia Richman High Schools, New York City;* and N. Eldred Bingham, *Horace Mann-Lincoln School, Teachers College, Columbia University.* Cloth. Pages v+719. 15.5×22.5 cm. 1944. Ginn and Company, Statler Office Building, Park Square, Boston, Mass. Price $2.24.

AIRCRAFT ANALYTIC GEOMETRY, (Applied to Engineering, Lofting, and Tooling) by J. J. Apalategui, *Tooling Project Supervisor, Lofting Departments, Douglas Aircraft Company, Inc.*, and L. J. Adams, *Head of Department of Mathematics, Santa Monica Junior College*. Cloth. Pages xiii+285. 13×21 cm. 1944. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $3.00.

GENERAL PHYSICS, A TEXTBOOK FOR COLLEGES, by Oswald Blackwood, Ph.D., *Professor of Physics, The University of Pittsburgh*. Cloth. Pages viii+622. 13.5×21.5 cm. 1943. John Wiley and Sons, Inc., 440 4th Avenue, New York, N. Y. Price $3.75.

ARITHMETIC FOR ADULTS, A REVIEW OF ELEMENTARY MATHEMATICS, by Aaron Bakst. Cloth. Pages vii+319. 13×19.5 cm. 1944. F. S. Crofts and Company, 101 Fifth Avenue, New York, N. Y. Price $2.00.

CELESTIAL NAVIGATION, A PROBLEM MANUAL, by Walter Hadel, M.A., *First Navigator and Chief Navigation Instructor, United Air Lines*. Cloth. Pages xiii+261. 13×21 cm. 1944. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.50.

TWENTIETH CENTURY ENGINEERING, by C. H. S. Tupholme. Cloth. Pages xi+201. 14×22.5 cm. 1944. Philosophical Library, 15 E. 40th Street, New York, N. Y.

GENERAL MATHEMATICS IN AMERICAN COLLEGES, by Kenneth E. Brown, Ph.D., *Teachers College, Columbia University*. Contributions to Education, No. 893. Cloth. 167 pages. 15×23 cm. 1943. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $2.35.

AIRPLANE ENGINE MECHANICS QUESTIONS AND ANSWERS, by Rolla Hubbard, *Instructor, Flight Engineer School, Pan American Airways, Instructor for New York City Board of Education War Industries Training Program;* and Augustin Dilworth, *Inspector, American Export Airlines, Consulting Editor of Aviation Redbook*. Cloth. Pages vii+260. 12×18.5 cm. 1944. McGraw-Hill Book Company, 330 West 42nd Street, New York 18, N. Y. Price $2.25.

ELEMENTS OF BIOLOGY, by Perry D. Strausbaugh, Ph.D., *Professor of Botany, West Virginia University*, and Bernal R. Weimer, Ph.D., *Professor of Biology, Bethany College, West Virginia*. Cloth. Pages vii+461. 13.5×21.5 cm. 1944. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $3.25.

PLANE AND SPHERICAL TRIGONOMETRY, by Howard P. Doole, *Assistant Professor of Mathematics, University of Nebraska*. Cloth. Pages viii+183. 12.5×19 cm. 1944. Thomas Y. Crowell Company, 432 Fourth Avenue, New York 16, N. Y. Price $1.75.

ELECTRICAL ESSENTIALS OF RADIO, by Morris Slurzberg, B.S., M.A., and William Osterheld, B.S., M.A., *Instructors of Electricity and Radio in the Wm. L. Dickinson High School and in the Evening Technical and Industrial High School, Jersey City, New Jersey*. Cloth. Pages xi+529. 13×21 cm. 1944. McGraw-Hill Book Company, 330 West 42nd Street, New York 18, N. Y. Price $3.00.

HOW TO PASS RADIO LICENSE EXAMINATIONS, by Charles E. Drew. Second Edition. Cloth. 320 pages. 16.5×24 cm. 1944. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $3.00.

FUNDAMENTALS OF PLANE GEOMETRY, by Joseph A. Nyberg, *Instructor in Mathematics, Hyde Park High School, Chicago, Illinois.* Cloth. Pages vii+359. 13.5×18 cm. 1944. American Book Company, 88 Lexington Avenue, New York, N. Y. Price $1.48.

FUNDAMENTALS OF ALGEBRA, by Joseph A. Nyberg, *Instructor in Mathematics, Hyde Park High School, Chicago, Illinois.* Cloth. Pages vi+336. 13.5×18 cm. 1944. American Book Company, 88 Lexington Avenue, New York, N. Y. Price $1.40.

ILLUSTRATED TECHNICAL DICTIONARY, Edited by Maxim Newmark, *Author of A Dictionary of Science and Technology in English, French, German, Spanish.* Cloth. Pages vi+352. 15×23 cm. 1944. The Philosophical Library, New York, N. Y. Price $5.00.

PHYSICS WORKBOOK, by Mahlon H. Buell, *Department of Physics, Senior High School, Ann Arbor, Michigan;* Frederick W. Schuler, *Department of Physics, West High School, Madison, Wisconsin;* and Edited by W. R. Teeters, *Supervisor of Physical and Biological Sciences, St. Louis Public Schools,* St. Louis, Missouri. Revised. Paper. Pages vi+378. 19×26 cm. 1944. J. B. Lippincott Company, 333 West Lake Street, Chicago 6, Ill. Price $1.12.

WHILE FATHER'S AWAY. Cloth. 112 pages. 11×18 cm. 1944. Published by The John Day Company, Inc., 2 West 45th Street, New York, N. Y. Price $1.50.

A B C's OF SCAPEGOATING, by Professor G. W. Allport, and Professor H. A. Murry of *Harvard University.* Paper. 72 pages. 15×23 cm. Central YMCA College, 19 South La Salle Street, Chicago, Ill. Price 25 cents.

RADIO AND ELECTRONICS. Paper. 16 pages. 15×21.5 cm. Published by Department of Information, Radio Corporation of America, RCA Building, 30 Rockefeller Plaza, New York, N. Y.

F M BROADCASTING. Issued by RCA Laboratories. Paper. 45 pages. 15×22.5 cm. Radio Corporation of America, 30 Rockefeller Plaza, New York, N. Y.

FEDERAL AID FOR EDUCATION NOW. Paper. 60 pages. 15×23 cm. National Education Association of the United States, 1201-16th Street, N.W., Washington, D. C.

PRE-INDUCTION TRAINING. A PROGRAM DEVELOPED FOR THE ARMY BY THE INDUSTRIAL PERSONNEL DIVISION HEADQUARTERS, ARMY SERVICE FORCES, James P. Mitchell, *Director.* Paper. 26 pages. 20.3×26.5 cm. Washington 25, D. C.

PHYSICS WORKBOOK AND LABORATORY GUIDE, by Harry R. Gail, *Assistant Research Engineer, University of Pennsylvania.* Paper. Pages v+394. 18.5×26 cm. 1944. Ginn and Company, Statler Office Building, Park Square, Boston, Mass. Price $1.32.

SHORT COURSE IN COMPUTATION, by Clifford B. Upton. Paper. 176 pages. 18.5×24.5 cm. 1944. American Book Company, 88 Lexington Avenue, New York, N. Y. Price 56 cents.

SHOP JOB SHEETS IN RADIO, BOOK I—FUNDAMENTALS, by Robert Neil Auble, B.S., A.B., *Instructor in Radio, Arsenal Technical Schools, Indianapolis and Supervisor, Signal Corps Radio School, Indianapolis.* Paper. Pages iii+134. 20×28 cm. 1944. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.50.

BOOK REVIEWS

THE ORIGIN OF THE CAROLINA BAYS, by Douglas Johnson, *Professor of Geology in Columbia University*. Cloth. Pages xi+341. 16×23.5 cm. 1942. Columbia University Press, Morningside Heights, New York, N. Y. Price $4.50.

Recent aerial photographic surveys show the Atlantic coastal plain in the Carolinas to be well covered with many depressions resembling meteoric craters. A few of these have been known for a long time and their origin has been highly publicized as due to meteorites that struck the earth at an angle. Dr. Johnson discusses this theory completely, pointing out both the evidence in its support and its points of weakness. He then offers a new hypothesis which seems to him to be the most reasonable explanation, but which he admits may be greatly modified or completely replaced by another of different character. This book is an excellent review of the progress that has been made in the solution of an unsolved problem of geology, and shows how development in another field (here aerial photography) may greatly aid in the study of an important feature in a fundamental science.

G. W. W.

A GUIDE TO NAVAL AVIATION, by Lt. Wallace W. Elton, USNR; Lt. Alfred H. Driscoll, USNR; Lt. Robert N. Burchmore, USNR; and Lt. Gray B. Larkum, USNR; *Instructors, U. S. Naval Air Station, Quonset Point, R. I.* Cloth. Pages ix+296. 13×21 cm. 1944. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.50.

This is a first book for those preparing for work in the Navy Air Force. It is largely descriptive but gives some explanatory work on the forces supporting an airplane in flight, piloting and aerial navigation, all of which requires some knowledge of geometry and graphical representation of forces and of the instruments used. A ten page glossary is given early in the book which the student will need to consult continuously until it is completely learned. An excellent short chapter on the power plant is included but this, like nearly all other sections, is too brief to give more than an elementary view. The excellent selected references following nearly all chapters will enable the serious student to go much farther. Understanding and memory are stressed. The book covers briefly practically every topic of major interest to the student preparing for this branch of service, including the aircraft carrier, guns and ammunition, air organization, traffic control, aerial navigation, weather, and the instruments and machinery used. It provides material for an excellent short course for the beginner but he should have previously taken the regular courses in high school algebra, geometry, and physics.

G. W. W.

MATHEMATICS FOR NAVIGATORS, by Delwyn Hyatt, Commander, USN, (Ret.) and Bennett M. Dodson, Commander, USNR. Cloth. Pages vii+106. 13×19.5 cm. 1944. McGraw-Hill Company, Inc., 330 West 42nd Street, New York, N. Y. Price $1.25.

The authors have written this book for two classes of students: (1) those who are interested in the study of navigation but do not have sufficient mathematical background; (2) those who need to review their mathematics for the study of navigation. It consists of seventeen pages of arithmetic, most of which deals with position and time; twelve pages of algebra emphasizing simple equations, time, speed, distance, propeller pitch and slip; seven pages on logarithms; eleven pages on plane geometry; sixteen pages

of plane trigonometry; and forty pages of spherical trigonometry. It is the opinion of the reviewer that the book may be of considerable help to the second group mentioned above but it is entirely inadequate for the first group.

G. W. W.

THE TEXT-ACTIVITY BOOKS, Copyrighted by the Harter Publishing Company, published by Kenworthy Educational Service, Buffalo, New York.

WHAT TREE IS THAT, Book 1 and Book 2 by J. E. Potzger, Ph.D., *Department of Botany, Butler University, Indianapolis, Indiana.*

Each of these books consists of 64 pages of interesting activity work for the grade school pupils. About the first sixteen pages of each book consists of general information about the deciduous trees of the eastern section of our country—general knowledge that everyone should know, but very few do know. This is followed by short descriptive accounts of many of our common forest and shade trees. Numerous short tests occur at fairly regular intervals.

BIRDS, Books 1, 2 and 3 by J. E. Potzger and Gladys M. Friesner, *Teacher in the Indianapolis Schools.*

These books follow much the same plan as the tree books, but give the youngsters some of the most important information about the common birds of this country—45 birds are described and illustrated. Every child will like the stories, descriptions and tests. The books provide interesting activities and give a wealth of information for all the years to come.

INSECTS AND SOME OF THEIR RELATIVES by J. E. Potzger and Margaret Esther Whitney, Ph.D., *Department of Biology, Central Normal College, Danville, Indiana.*

This book is also written for grade and junior high school children. It gives some of the most fundamental information about the many insects, both harmful and beneficial.

Try out these books. They will make the trouble-maker a real science student.

G. W. W.

ELEMENTARY TOPOGRAPHY AND MAP READING, by Samuel L. Greitzer, *Bronx High School of Science, New York City.* Cloth. 10 chapters, 150 figures and illustrations. 15×22.5 cm. 1944. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York City. Price $1.60.

A much needed text on maps for the secondary school. Gives the beginner an excellent training in understanding and using maps. An explanation of map development, the different map types and their application to various problems. The chapters on contour maps and their use is practical and might even be extended somewhat. Good field use of maps and a fine introduction to aerial photography and its relation to mapping.

VILLA B. SMITH

EARTH SCIENCE. A Physiography, by Gustave L. Fletcher, of *James Monroe High School, New York City.* Cloth. 33 chapters, 583 pages, 352 diagrams and illustrations. 15×21 cm. 1943. D. C. Heath & Co., Boston, Mass. Price $2.20.

This text is based upon New Physiography by Arey, Bryant, Clendenin and Morrey. Physiography has been almost replaced by General Science in most secondary schools but it seems to this reviewer that it offers a sound basis for biology, political geography, advanced climate and weather studies, and an understanding of conservation. The chapters on atmos-

phere, weather and climate give the modern explanations and are well done. The chapter on "Stories in Stone" is abbreviated paleontology and is of doubtful value which the author recognizes by making it optional. A full chapter on map studies would have been of more use than to place such an important subject in the appendix. The completion summaries and exercises at the end of each chapter are good. The book is well adapted to prepare pupils for the New York State Regents examinations.

VILLA B. SMITH

SHOPWORK, by Edward C. Wicks, *Instructor of Industrial Arts, Morristown High School, New Jersey*, John Poliacik, Jr., *Instructor of Industrial Arts, Morristown High School*, and John Ellberg, *author of Tales of A Rambler*. First Edition, pages viii+160. 139 Figures. 17×24 cm. Cloth. 1943. American Book Company, 360 N. Michigan Ave., Chicago, Ill.

SHOPWORK, another "must book" for Pre-induction Training, has been written to conform to the Pre-induction Training Course in Fundamentals of Shop as prepared by the War Department. The text covers the material in a rather succinct and to-the-point style, and yet is easily grasped by the average high school junior and senior. Problems are conveniently placed after each section under discussion. The approach to each unit is made interesting by a modicum of relevant subject matter and well selected modern photographs. One is conscious throughout the book that little supplemental teaching becomes necessary. Some of the illustrations showing threads may be subject to criticism on the part of those who are more critical.

LUMIR P. BRAZDA
Bowen High School, Chicago

SHOP PRACTICE, by William J. Kennedy, *Instructor of Machine Shop Practice, Straubenmuller Textile High School, New York City*. First Edition pages viii+338. 329 Figures. 14.5×22 cm. Cloth. 1943. John Wiley and Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $1.52.

The writer has compiled in this text subject matter to meet the requirements of the War Department and the United States Office of Education as specified in the Pre-Induction Training Course Outline No. P. I. T. 103. The material has been "pointed" to military needs, while emphasizing the mechanical skills so essential to a mechanized army. The book will serve as an aid in training students in fundamentals of mechanical work and related skills in specific tasks. It is written in language understandable by the average high school junior or senior who will use it as a textbook. Questions at the end of each chapter direct the student to important parts within that portion. The appendix supplies data on fractional decimal equivalents, simple mathematical formulae, mechanical expressions, wire gages, drills, taps, and other such material. Throughout the text figures supplement the written word. The presentation has been orderly, complete, and clearly expressed.

LUMIR P. BRAZDA

PLANE TRIGONOMETRY AND STATICS, by Norman Miller, *Professor of Mathematics in Queen's University, Kingston*, and Robert E. K. Rourke, *Associate Headmaster and Instructor in Mathematics at Pickering College, Newmarket*. Cloth. Pages vii+427. 21×15 cm. 1943. The Macmillan Company of Canada Limited.

This text presents a thorough treatment of Trigonometry, Applied Trigonometry is taken up first. The problems here are practical and com-

putational in character. The formulas for the solution of triangles are derived geometrically.

Analytic Trigonometry follows. The important formulas are exhibited in brackets in heavy black type. The part on Statics covers resolution of forces, moments, center of gravity, friction, Newton's third law, and machines.

The parts on Applied and Analytical Trigonometry give a thorough course in Trigonometry, much stiffer than is usually offered in the United States. Statics in this country is usually offered as a separate course.

JOHN J. CORLISS

THE STORY OF FLYING, by Archibald Black. Revised Edition. Cloth. Pages xiv+272. 14.5×22.5 cm. 1943. Published by Whittlesey House, a division of the McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y. Price $2.50.

This is an edition of a sweeping and incident-packed chronicle of man's conquest of the air, beginning with his earliest aspirations and ending with his plans for the future. It adds material on the development of aviation in the Second World War, including a discussion of the Battle of Britain, the U. S. Army Pilot training program, the battleship versus the airplane in war, and the transatlantic airlines, as well as such specific advances as the Sikorsky helicopter and the Martin "Mars."

The author's personal experience in aviation goes back to 1910 and since 1915 he has devoted his time almost continuously to aviation engineering. This long experience enables him to picture clearly the struggles and rewards of the men who made aviation and the little-by-little development of the airplane from a crude beginning to the last word in stratoliners.

The Story of Flying gives only enough of the high lights to create a mental picture of each period in the development of the balloon, airship and airplane. In addition to the main story there follows separate stories of Engines and Propellers; Rotary Wings; Airports, Airways and Radio; Photography and other uses of the airplane; Interesting Devices; Modern Transportation and Recent Events.

Teachers of pre-aviation courses in high school will find this book an invaluable reference text for data on the history of aviation as well a splendid source for student reading reports.

ESTIL B. VAN DORN
George Washington High School, Indianapolis, Indiana

ELECTRICITY FOR EVERYONE, by Joseph R. Lunt, *late Professor of Science at Rhode Island College of Education*, and William T. Wyman, *Practical Electrician, Chairman of Electrical Department, Central High School, Providence, R. I.* Cloth. Pages ix+649. 14×21 cm. 1943. The Macmillan Company, 60 Fifth Ave., New York. Price $2.56.

This book is designed to provide a knowledge of the applications of electricity and some of the theories and laws that stand behind our mastery of this mysterious force which has given us our modern world.

The text is organized on a progressive plan. Simple facts and experiments make clear fundamental principles. The study moves from flashlights to television, and from the horseshoe magnet to great transformers and power plants. Each chapter begins with simple applications, moves on to more difficult applications and principles, and concludes with thought provoking review questions.

Safety Education is stressed throughout the book in relation to the use and care of electrical equipment in the home. Warnings against the exposure of oneself to the dangers of the use of electricity is very cleverly

presented in discussions of the wiring of the home, inspection of wiring, safety from fires of electrical origin, safety from electric shock and first aid for electrical shock, etc.

A very full treatment of three fields of Amusement: Radio, Motion Picture, and Television will be found in later chapters of this book.

There are 101 interesting photographs, 274 diagrams, many interesting tables of practical information and much other material which is not found in the conventional physics books. The descriptions and discussions of electrical equipment in large industrial plants of this country are very well done. Some of the outstanding plants and their equipment are "The Boulder Dam Power System"; "Bonneville-Columbia River Power System"; "The Boulder Dam and Los Angeles Transmission System"; "Distribution of Electric Power"; "Direct Current Substations"; "Three-Phase, Three Wire System Compared to the Three Wire Edison System"; "Electrical Refrigeration"; "Recommendations for Local Lighting"; and "The Lead-acid and Edison Storage Batteries."

Directions are given for the making of 25 or more models of electrical apparatus ranging from a model flashlight to a home-made two-circuit radio set or photoelectric relay. There are about 20 pages of study helps and a Glossary of most commonly used electrical terms.

ESTIL B. VAN DORN

AIR NAVIGATION FOR BEGINNERS, A GROUND SCHOOL PRIMER FOR AERIAL NAVIGATORS, by Scott G. Lamb, B.S., M.S. *Lieutenant Commander, U.S Navy, Retired Instructor in Navigation Air-War Navigation Schools, Franklin Institute, Philadelphia* with the cooperation of Mrs. Harry Thomas Jordan, *National Wing Commander, Junior Air Reserves National Aeronautic Association*. Cloth. Pages 103. 13×19.5 cm. 1942. The Norman W. Henley Publishing Co., 17 West 45th St., New York, N. Y.

There are eleven chapters with questions and answers. Each chapter gives a brief discussion of the subject at hand and one or more examples of problems and their solution covering the work of the chapter. Although very brief, each lesson is to the point and the beginning student will find the problems can be solved by referring to the solutions of the examples. Some of the main subjects treated are as follows: measurement of position; navigational instruments and their uses; piloting and radio bearings; dead reckoning and the wind triangle; radio range system; flight instruments and corrections; and a short discussion of aerial astronomy and time.

ESTIL B. VAN DORN

ESSENTIALS OF ALGEBRA (COMPLETE SECOND YEAR COURSE), by Walter W. Hart, author of a series of mathematics texts. Cloth. Pages vii+472. 13×20 cm. 1943. D. C. Heath and Company, 285 Columbus Ave., Boston, Mass. Price $1.68.

This text is an extension of the author's *Essentials of Algebra, Second Course* (1941), and is intended for schools that give a year's course in second year algebra, and especially for schools that give advanced or college algebra. The author states in the preface that "the chapters on college algebra are quite adequate for normal schools and colleges."

The first half of the book contains a review of the first course in algebra. This part is practically the same as *Essentials of Algebra, Second Course*, with the addition of such new topics as joint variation, Pascal's triangle and a brief introduction to the slide rule as an application of logarithms. The chapter dealing with equations of higher degree is largely rewritten from a higher point of view and introduces as new material the quartic function, and various topics from the theory of equations, such as complex roots,

transforming equations, Horner's Method and Descartes' rule of signs.

The second half of the book contains much new material. Included in this are chapters on permutations and combinations, probability, determinants (including fourth order determinants and seven theorems for expanding determinants, assumed without proof), mathematical induction and indeterminate forms. An introduction to analytic geometry and calculus is afforded in deriving the slope and y-intercept form of the straight line, the slope and one point form and the two point form; rates of change; finding some simple derivatives; and partial fractions. The book is completed with sections devoted to the vector addition and subtraction of complex numbers, numerous reviews, self-tests, cumulative reviews, problems and tables. There is an abundance of graphs, diagrams and illustrations. The book deserves the attention of any school offering a full year's work in advanced algebra.

GLENN F. HEWITT,
Von Steuben High School
Chicago, Ill.

SOLID GEOMETRY, by F. Eugene Seymour, *Supervisor of Mathematics, New York State Department of Education*, and Paul James Smith, *Head of Department of Mathematics, East High School, Rochester, New York.* Cloth. Pages vii+263. 14×21.5 cm. 1943. The Macmillan Company, 60 Fifth Ave., New York City. Price $1.60.

Besides the usual topics of solid geometry, the authors include numerous exercises for each unit graded into three groups of difficulty; a brief review of the essentials of the unit; two tests for each unit and a cumulative review. Many military and navigation problems are given. Many of the exercises apply the elementary principles of trigonometry and the theory of logarithms. One of the chief innovations found in this text is the inclusion of a unit on spherical trigonometry. In this the formulas used in the solution of the right spherical triangle are all derived by geometric means. Then the methods of solving oblique spherical triangles are considered. Extensive use of logarithms is made in this unit. The book abounds with historical notes; a proof of Euler's theorem concerning the edges, faces and vertices of a polyhedron is given; included also is an informal discussion of co-ordinates in space.

GLENN F. HEWITT

MODERN SCIENCE SERIES, by Charles E. Dull, *Supervisor of Science for the Junior and Senior High Schools of Newark, New Jersy and Head of the Science Department in the West Side High School;* Paul B. Mann, *Head of the Biology Department in the Evander Childs High School in New York City;* and Philip G. Johnson, *Editorial Consultant for the Modern Science Series and Assistant Professor of Education at Cornell University, Ithaca, New York.* MODERN SCIENCE IN OUR ENVIRONMENT, Book 1. Cloth. Pages viii+432. 13.5×20.5 cm. MODERN SCIENCE IN OUR DAILY LIFE. Book 2. Cloth. Pages viii+502. 13.5×20.5 cm. MODERN SCIENCE IN MAN'S PROGRESS. Book 3. Cloth. Pages ix+598. 13.5×20.5 cm. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y.

The series Modern Science In Our Environment, Modern Science In Our Daily Life, and Modern Science In Man's Progress is outstanding in many respects. There has been a growing feeling among junior high school science teachers that the repetition of topics with supposedly different emphasis as the junior high school series of the past have been constructed is not the best for maintaining pupil interest. This series is different because this repetition of topics in each book does not occur and each book is complete in itself in topics treated.

The organization of material is similar to other books in having a preview to the unit which is broken up into chapters. Each chapter has motivating questions and a list of new words with syllabication and pronunciation as shown by diacritical marks which are needed for the study of the chapter. This is an outstanding feature of the book. In all of the studies on vocabulary it is generally understood that general science is the most difficult because of the number of new words confronting the young child. The style of writing is simple and direct. The sentences are short and make understanding easy. All the new words or familiar words with new meanings needed for understanding are listed at the beginning of the chapter and are italicized the first time they are used in the chapter. At the end of the chapter are questions and activities the child can do at home or at school. Some of the answers to the questions are in the text and some call for further work thus carrying the study beyond the book. The experiments needed for better understanding of the text material are so set off on the page in the chapter that they do not break up the continuity of thought. The diagram and picture give a complete story of the experiment presented. The pupil will have a reading knowledge of the experiment instead of a vague guessing knowledge as in other texts which have the formal presentation with questions about observations which in most cases were never made.

There are many other features which make the series outstanding; such as the definite attempt to use space relationships with which the child is familiar in explaining the sizes of things; the explanations of words used is given immediately in the phrase that follows thus resulting in immediate understanding; the human personal touch in telling about people associated with the development of new ideas; questions which require more than one word for an answer and some require further study for a good answer; all illustrations have meaning to the inexperienced child because the explanation is given right with the picture; and much valuable book space saved by having a good bibliography at the end of the book; and a glossary that can really be used because it is complete enough for over three-hundred words are in each book.

There are eighteen chapters in Modern Science In Our Environment and the topics are in general: plants, animals, air, water, earth's surface, and reproduction. There are nineteen chapters in Modern Science In Our Daily Life and the topics covered in general are: water, weather, heat, clothing, communication and the human body. There are twenty-three chapters in Modern Science In Man's Progress and the topics covered are in general: astronomy, food, homes, light, machines, electricity, transportation, communication, health, and improvement of living things.

PAULINE ROYT,
Milwaukee, Wisconsin

ORGANIC CHEMISTRY, by C. W. Porter and T. D. Stewart, *Members of the Faculty of the College of Chemistry in the University of California.* Cloth. Pages v+577. 14.5×22 cm. 1943. Ginn and Company, Statler Building, Park Square, Boston, Mass. Price $4.00.

This book is an outgrowth of *The Carbon Compounds* which for many years has been widely known as a textbook for courses in organic chemistry. In their latest venture in this field, the authors preferred to write a new book rather than to limit themselves to a mere revision, no matter how extensive, of an old text.

The book consists of an introduction, twenty-five chapters, supplementary notes, an appendix, and a section devoted to questions and problems. In the introduction, the authors present a rapid, preliminary survey of the

main classes of organic compounds and the principal types of chemical reactions. In the chapters which follow, these classes of compounds are discussed in detail.

Twelve chapters are devoted to the aliphatic hydrocarbons and their derivatives while six consider the aromatic compounds. The general order of treatment in each chapter is structure, isomerism, homology, preparation, reactions, and important members of the series.

The emphasis in each of the chapters is upon type rather than upon many individual reactions although specific examples are used to illustrate these type reactions. The authors have not attempted to present all the chemistry of any particular class of compounds but to include all reactions which are commonly used so that the student will find little in the literature with which he does not have some familiarity. The mechanism of some reactions has been included.

There is considerable treatment of modern developments in the field of organic chemistry. In the chapter on the aliphatic hydrocarbons, synthetic rubber and gasoline are discussed. Two chapters are devoted to biological processes.

In the supplementary notes and appendix, the author presents some of the many applications of physical chemistry to organic reactions. At the end of the book, there is a large number of exercises and problems of varying degrees of difficulty.

The textual material is clear and concise; the English is good; the size of type and bold-faced paragraph headings make for ease of use. Few errors are apparent in the text. Undoubtedly this will become a widely used reference and textbook.

ANNA LOUISE BURLINGAME
Tuley High School, Chicago

MAN'S PHYSICAL UNIVERSE, by Arthur Talbot Bawden, *President of the Stockton Junior College, Stockton, California.* Revised edition. Cloth. Pages xv+832. 15×23.5 cm. 1943. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.00.

Man's Physical Universe is written for use as a text in either pre-induction or regular survey courses in physical science. Its purpose is to deal with the problems of life today.

In the author's words it "is designed to bring from the archives of physical science the most important facts and generalizations which have any bearing on these problems . . . to survey the phenomena of the physical universe with reference to man's immediate environment, . . . and to show how man is gaining control over the forces of nature and harnessing them to do his work."

The book is divided into ten units, and these are subdivided into ninety-six sections each of which is a single class assignment in itself.

Unit I discusses the need of scientific solution of problems. Units II and III are devoted to astronomy and geology respectively. The next four units pertain to physics and the last three to chemistry. In unit IV, "Man Applies His Knowledge of Physical Properties and Physical Changes to Overcome Many Physical Limitations," the author carefully integrates the physical properties of the three states of matter and changes of state with climate and weather. One section is given to weather forecasting and another to air-conditioning. In unit V, "Man Has Discovered and Harnessed Different Forms of Energy," a section is devoted to avigation. The three units on chemistry are unusually good. Recent developments such as plastics; synthetic rubber; and vitamins, enzymes, and hormones are considered.

At the end of the book, the author has included a twelve page bibliography. This is not subdivided by sections but gives references for each of the ten units.

Each section is followed by a series of study questions. The only criticism is that these are all essay in nature. None gives the student the opportunity to exercise scientific method. For example, in unit I, section 4, when the metric system is discussed, the author affords the student no opportunity to familiarize himself with this new system of measurement through the solution of problems.

The textual material is clear and concise. It has been "detechnicalized" as much as possible. The author has fulfilled his stated purpose of taking the "individual slices of knowledge" of the various physical sciences and trying "to fit these slices together and to discover a pattern running through all of the sciences that will provide not only intelligent but useful knowledge."

ANNA LOUISE BURLINGAME

MAN AND HIS PHYSICAL UNIVERSE, by Frank Covert, Jean Ezra Clarence Harrah, and Fred Louis Herman, *Colorado State College of Education*, with the editorial collaboration of Samuel Ralph Powers, *Teachers College, Columbia University*. Cloth. Pages viii+608. 15×22.5 cm. 1943. Ginn and Company, Statler Building, Boston, Mass. Price $3.25.

The authors have pointed their book to the needs of the large number of students who do not intend to specialize in science but who will be greatly benefited by an adequate understanding of the application of scientific facts and discoveries to everyday life. It is their intent that *Man and His Physical Universe* shall be used in a course in which "the generalizations and understandings of science shall be developed in such a way as to influence significantly the beliefs, philosophy, behavior, and attitudes of the future citizens of our democracy."

The book is divided into six units which cover the fields of astronomy, physics, chemistry, meteorology, and geology. In order to maintain student interest and at the same time to show the relationship of the various fields to modern life, the authors have given their units such titles as "Man's Increased Knowledge of the Cosmos Has Modified His Thinking," "Matter as Organized Energy Possesses Properties Which Are Indispensable to Man," and "Energy in Many Forms Is Used by Man to Advance Civilization."

The book is not organized in terms of problems for instruction but presents a non-mathematical descriptive account of scientific facts. It includes historical narratives, discussion of techniques used by scientists in making their discoveries, etc. The authors have left it to the individual instructor to define the problems and to the individual student to select the material which is pertinent to the solution of such problems.

The sections on geology and chemistry seem better organized than that on physics. Any consideration of motion, forces, and the effect of forces on motion has been omitted.

The authors have formulated a series of questions at the end of each chapter but these require only the ability to generalize from textual material. None is mathematical in nature. The reference list at the end of each section includes textbooks in the various fields, popular books on science, and industrial pamphlets.

This text should be interesting to the non-scientific reader. The composition is good, most illustrations are well-chosen, and the material has been carefully related to the layman's everyday life.

ANNA LOUISE BURLINGAME

ELEMENTARY ELECTRICITY, by Edgar P. Slack, *Assistant Professor of Physics, Polytechnic Institute of Brooklyn.* Revised Edition. Cloth. Pages ix+305. 13.5×20.5 cm. 1943. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.00.

A book used primarily in technical and vocational schools as an introductory textbook for students who have not studied electricity. It has been revised to meet the needs of preinduction classes by omitting certain subjects and expanding the discussions of magnetism and static electricity. Appendices A and B have been added, and it is assumed that they will be taken up first. The approach to the subject is via the electron theory, and the subject is so developed that it unfolds with pleasing logical sequence. The treatment of the subject of alternating current is outstanding and highly practical. Alternating current motors are discussed briefly, induction motors being the chief topic of the discussion. The illustrations are unusual inasmuch as they are not the usual copied illustrations but are especially drawn for this particular text. Among the outstanding features of this book are the discussions of common electrical troubles; trouble shooting; and methods of remedying the situation. The discussion of direct current equipment is outstanding in its treatment. Problems and questions for review are provided at the end of each chapter. Examples are provided to show how to make the necessary mathematical calculations.

ROGER J. WEAVER

WILLKIE ON EDUCATION

There is a basic relationship between a liberal education and freedom. The greatest civilizations of history have been the best educated civilizations.

The present greatness of the United States is directly related to the fact that one-fourth of our people are high-school graduates and that we have a larger percent of high school and college graduates than any other country; yet there are tens of millions of our adults who have been denied the chance to become well-educated and there are millions of our children who under present conditions wil lbe denied all but a meager elementary training.

A good education is the right of every American child, irrespective of race, creed, parental wealth or place of residence. In this day of complicated problems and involved issues, a good education is needed by every voter if our freedom is to be maintained. The continuance of our democracy in the perilous days ahead depends upon the education, good judgment and unselfishness of our voters. National interest demands that all of our people be well educated. They must understand the foundations upon which our individual liberties and the protection of our minority groups are based. They must know the major lessons from history and must have some knowledge of economics and government. This calls for at least a high school education for the masses of our people.

My greatest criticism of American education is that we have not had enough of it. The American educational system has set men free, free not alone to serve but free to lead. Education is the mother of freedom and leadership but so far we have failed to provide the quality and quantity of education needed to safeguard our future. Twenty-nine percent, or 19,000,000 of our adults have a sixth grade education or less. Fifty-nine percent of our population have not gone farther than the eighth grade. Today there are 3,000,000 children of high-school age not in school. Such failure to de-

velop human ability can no longer be afforded in view of the difficulties ahead of our country.

There are those who say we cannot afford better schools. I say we cannot afford to allow children to grow up in ignorance, nor permit poor schools or inadequate education to exist in this democracy. Education is of such importance that its needs must be met even if this means the deferring of our public activities of less moment.

I want to pay tribute to the more than 1,000,000 American teachers who under great hardships and adverse conditions have remained in the schools during this war period and who are doing their best for the children of the nation. They need our support and the stimulation of our recognition of the importance of their work. We must see to it that these important public servants are no longer overlooked but that they be given the assistance necessary to provide the good education we desire and need for every American child.

WENDELL L. WILLKIE

SYNTHETIC RUBBER

In 1826, Michael Faraday, the British scientist, discovered that natural rubber was composed of five atoms of carbon to eight atoms of hydrogen, and was, like oil, a hydrocarbon. In 1860, Grenville Williams, another Englishman, broke down natural rubber by heat, and derived a liquid with the same ratio of carbon to hydrogen as Faraday had reported. This liquid was isoprene, raw material for rubber. Experimenting with isoprene twenty years later, a Frenchman, G. Bourchadet, obtained a substance which had elasticity and some of rubber's other properties. In 1892 Sir William Tilden made isoprene from turpentine, but his synthetic was useless as he was unable to vulcanize it. In 1916 the Germans built and operated a plant which turned out synthetic rubber of an inferior grade by means of a long and expensive process. In 1921 the United States Rubber Co.'s Dr. I. Ostromislensky started his experiments which succeeded in making butadiene from ethyl alcohol. The following year that company turned out a successful synthetic by polymerization of emulsified butadiene, producing a synthetic rubber latex. (Polymerization is essentially a process in which little molecules are put together to make big ones.)

In the late twenties the price of natural rubber started to fall because of over-production in the Malay States and in the Netherlands East Indies, and by 1933 had dropped from its 1910 price of $3 a pound to 3 cents a pound. With natural rubber available in seemingly endless quantities, many firms abandoned the search for a substitute.

Shell oil was among those companies who continued their efforts to produce raw materials which could be used as a base for special purpose synthetics. Scientists of the "University of Petroleum," laboratories of the Shell Development Co. at Emeryville, Calif., developed a method for manufacturing butadiene from petroleum. From 1939 through 1941, a pilot plant at Emeryville made tons of butadiene available to American rubber companies. Months before Pearl Harbor, a full-scale butadiene plant was built and put into operation by Shell at Houston, Texas. The first commercial plant in the United States built for this purpose, the Houston plant produced more butadiene during 1942 than any other source in the country. As a part of the nation's enormous synthetic rubber program, another plant has been built at Torrance, Calif., and is being operated by Shell. The new plant alone expects to make available enough butadiene to manufacture between 100,000,000 and 120,000,000 pounds of rubber annually.

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